SPEECH PRODUCTION AND SHORT-

TERM MEMORY.

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To Anna, Martin and Hayden.

Abstract.

The thesis traces the historical development of concepts of short-term memory and discusses in detail one particular model of memory and language performance (the Logogen Model) proposed by John Morton. Within the Logogen Model, verbal short-term memory for disconnected items is mediated by a phonemic Response Buffer whose more normal function lies in the planning and preparation of speech. The theory is put forward that certain forms of speech error (phonemic 'slips of the tongue') are attributable to errors occurring at the Response Buffer, and that these error forms have equivalent counterparts in the errors occurring in traditional short-term memory experiments.

The experiments described draw upon studies of naturally-occurring speech errors in order to generate predictions as to how particular variables should influence short-term memory errors. Experiments I, II, IV and VI test a proposed equivalence between phonemic Spoonerisms in speech and transpositions in short-term memory. Experiments I and II show how two forms of phonemic similarity (feature similarity and contextual similarity) have comparable effects on Spoonerisms and transpositions. Experiment IV extends this comparability to the effect of syllable position on error distributions (an effect which is pursued further in Experiment V). Experiment VI fails to show any effect of linguistic stress on transpositions, in apparent contradiction of studies of speech errors. Experiment III demonstrates comparable effects of phonemic (feature) similarity on segmental replacement errors in speech and substitution errors in short-term memory, while Experiments VII and VIII explore the possible equivalence between phoneme masking in speech and a phonemic Ranschburg Effect in short-term memory. The thesis concludes with discussions of the detailed organization of the Response Buffer and ways in which disturbances at that level may result in a variety of language disorders.

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1.1. HISTORICAL SURVEY OF THE DEVELOPMENT OF INPUT MODELS.

1.1.1. The beginnings.

In 1870, Oliver Wendell Holmes, addressing the Phi Beta Kappa Society of Harvard University, said, " ... in uttering a series of unconnected words or letters before a succession of careful listeners, I have been surprised to find how generally they break down, in trying to repeat them, between seven or ten figures or letters; though here and there an individual may be depended on for a longer number ... " (Holmes, 1871, p.101). This passage is cited by Blankenship (1938) as being the first modern observation on the memory span. Fifteen years later, Ebbinghaus (1885, trans. 1964) reported his own ability to repeat a series of up to 7 or 8 nonsense syllables after a single reading of them, and considered this to be " ... a measure of the ideas of this sort which I can grasp in a single unitary conscious act". (Ebbinghaus, 1885, p.109).

Jacobs (1887) was responsible for the earliest systematic experiments on memory span. Jacobs read sequences of letters or digits, in a monotonous voice at a rate of 2 items per second, to schoolgirls of various ages who then tried to write down each sequence in its correct order. Memory span was defined for each subject as the longest sequence correctly recalled (2 sequences of each length being presented). The span for digits (mean 9.3) was found to be greater than that for letters (mean 7.3). Memory span was also found to increase with age (from an average of 6 letters at age 8 years to between 7.3 and 8.2 letters at 15 to 18 years), and also to be associated with position in the form (high span going with high position). In discussing these observations, Jacobs writes that, "This raises at once the question as to what is the exact power of the mind which is involved in reproducing these sounds ... We propose to call this power Prehension ... It may be described as the mind's power of taking on certain material ... we clearly cannot take in without first taking on, and the mental operation we have been testing thus seems a necessary preliminary to all obtaining of mental material." (Jacobs, 1887, pp. 78-79).

Jacob's paper is immediately followed in the same volume of Mind by an article from Frances Galton reporting on the very limited memory spans of "idiots" (Galton, 1887). This, along with Jacob's (1887) observations on the relationship between memory span and position in form, led to memory span being taken up by the exponents of mental testing and included in their tests of intelligence. Thence followed a period of forty years or so during which certain effects on memory span of rate of presentation, grouping, time of day, etc., were studied, but the main purpose was that of standardising and controlling memory span estimates. When Blankenship (1938) came to review the literature, the lack of theory-guided experimentation forced him to conclude that, " ... it is appalling to note how little real knowledge there is in the field of memory span." (Blankenship, 1938, P.18).

Insofar as the psychological processes underlying the memory span were considered prior to the 1950s, Jacobs' (1887) conception of the span as a measure of the mind's capacity to take in information continued to receive support. Thus, Warren's (1935) Dictionary of Psychology notes that the concept of memory span was not usually distinguished from that of attention span (Warren, 1935, P.163), and the widely-used textbook by Woodworth (1938)includes in its discussion of immediate memory span the statement that, "The concept of span, derived from the span of the hand, conveys the idea of width of grasp. How much can be spanned or grasped at once." (Woodworth, 1938, p.7).

Hence, when memory span, or more generally, short-term memory came to be viewed under the impact of information theory, as a reflection of the processes by which sensory information is transferred into long-term memory, that view fitted well with the earlier conception derived from Jacobs (1887) and Ebbinghaus (1885).

1.1.2. The impact of information theory.

Throughout the 1950s, and into the 1960s, the dominant metaphors in the new field of information-processing psychology came from information theory. Information theory originated within communication engineering and, from the standpoint of the theory, the human being is seen as a transmitter of 'information' within a communication system (Miller, 1956; Cherry, 1966). 'Information' as defined within information theory, is a measure of the "surprise value" of an event, and increases as the statistical probability of the event decreases. Thus, a letter presented to a subject as an experimental stimulus carries more 'information' if it is selected at random from all 26 letters of the alphabet than if it is selected from a restricted set of letters.

Hayes (1952) and Pollack (1953) studied memory span as a function of the size of ensemble from which the items were drawn (that is, as a function of the amount of 'information' per item) and found that memory span depended on the number of items in the message, but not on the amount of 'information' conveyed by each item. This finding has been replicated by, among others, Conrad and Hull (1964), and Nevelsky (1970). That is, whilst memory span may reflect the limited capacity of a memory store in terms of discrete items, it does not support the concept of a transmission channel limited in terms of 'bits of information'. Miller (1956) argued, however, that it is possible to increase the amount of information conveyed per item by recoding (or 'chunking') items into shorter, but equivalent, units, (e.g. recoding the binary figures 1001, 1011, 0011, as the decimal digits 9, 11, 3).

Despite the failure of specific hypotheses from information theory to predict short-term memory performance, concepts such as information transmission, redundancy and channel capacity continued to exert strong influence, and were incorporated into the numerous diagrammatic models which served to embody developing psychological theories of short-term memory.

1.1.3. Broadbent's (1958) model.

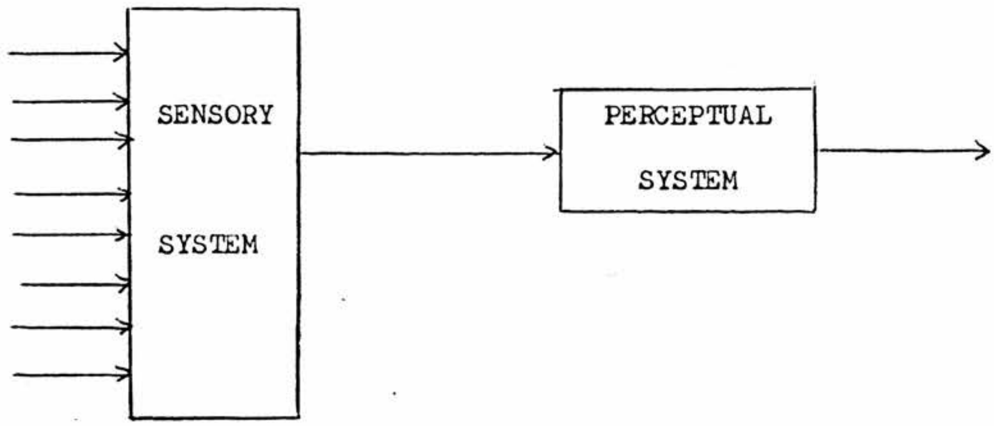


Figure 1.1. Broadbent's (1958) model for immediate memory.

The first widely acknowledged information-flow diagram to represent human performance in immediate (short-term) memory was presented by Broadbent (1958) as a development of an earlier "mechanical" model (Broadbent, 1957). In Broadbent's (1958) model, sensory information from the eyes or ears first enters a store (the Sensory, or S system) from which information is lost through decay in a matter of a few seconds unless that information is transferred into a second store, the Perceptual system (P system).

Information can enter the S system in parallel, but can only pass serially through the P system which is limited in the rate at which it can transmit items. All information must pass through the limited-capacity P system before it can be permanently registered in the long-term memory store. The limitations of the P system are held to account for the limits of the memory span. Silent rehearsal is envisaged as a circulation of information from the S store, through the P system and back again to the S store, repeated as necessary until a response is required.

1.1.4. Waugh and Norman (1965): a rapid-transit input model.

The second influential model of memory to be considered was put forward by Waugh and Norman (1965), and is reproduced as Figure 1.2.

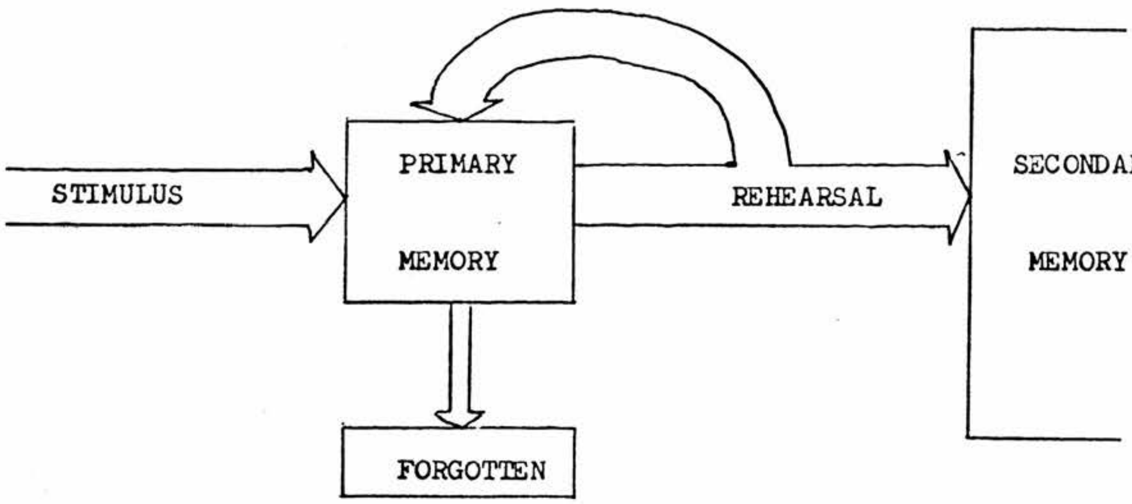


Figure 1.2. Waugh and Norman's (1965) model of primary and secondary memory.

In Waugh and Norman's (1965) model, the terms Primary Memory (PM) and Secondary Memory (SM) denote two distinct memory stores. PM is comparable to Broadbent's (1958) P system, being a store which occupies a position between peripheral sensory analysis and central Secondary (long-term) Memory. Every verbal item attended to enters PM, which is limited in terms of the number of items it can hold. New items entering PM displace old items which are thus lost from PM. Items are transferred to SM by rehearsal which re-enters an item into PM whilst, at the same time, registering the item in SM. It should be noted, however, that any verbal item consciously perceived is registered in SM since Waugh and Norman propose that, "The initial perception of a stimulus probably must also qualify as a rehearsal" (Waugh and Norman, 1965, P.92). Thus it is argued, "that most of the published data on short-term retention actually reflects the properties of both [PM and SM] systems" (p.101).

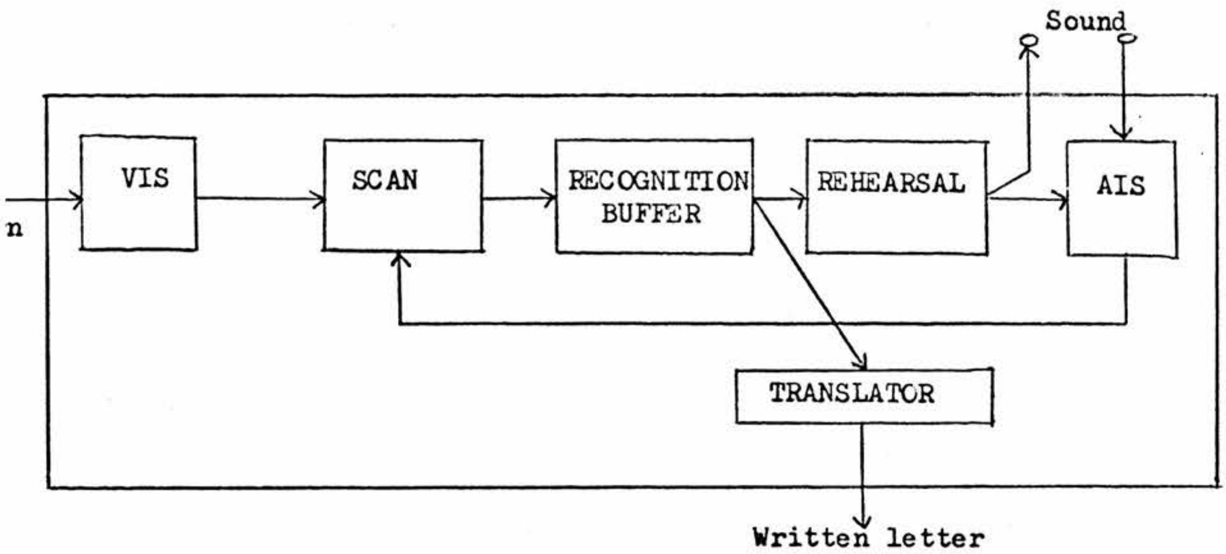
The advantage of using the terms Primary Memory and Secondary Memory to refer to hypothetical memory stores is that the terms short-term memory (STM) and long-term memory (LTM) can be retained for use in referring to experimental situations in which recall of items is required either immediately (STM) or after a delay in which rehearsal is prevented (LTM). Failure to observe this distinction may lead to severe theoretical confusion (see Section 1.2.).

Waugh and Norman also raise a number of question which they deliberately leave unanswered. For example, what exactly constitutes an "item"? Does storage in PM precede the attachment of meaning to verbal stimuli? In what form is information in PM coded? For suggestions concerning this last question, Waugh and Norman direct the reader to Sperling's (1963) suggestions on auditory storage which will be considered in the next Section.

Before leaving Waugh and Norman (1965), however, attention is drawn to the description of the model used in the heading of this Section. The model is described as "a rapid-transit input model". It is an input model because PM sits between senses and semantics - that is, between intake of information at the eyes or ears, and the permanent, meaningful encoding of that information in SM. It is a rapid-transit model because the first conscious perception of a stimulus is sufficient to achieve a registration of the stimulus information in SM, although the strength of the SM trace thus formed can only be increased by rehearsal, which is the prerogative of PM.

1.1.5. Sperling's (1967) model: articulation and acoustic coding.

The model for short-term memory proposed by Sperling (1967) was the development of an earlier model by Sperling (1963) and was, itself, further modified by Sperling (1970) and Sperling and Speelman (1970). The model (see Fig. 1.3.) grew out of a concern for the processes underlying the ability of subjects to report letters exposed visually in very briefly-presented arrays. Experiments involving partial report for such an array exposed for between 15 and 500 msecs indicated that far more information was present in the initial percept than the subject was normally able to report (Sperling, 1960). This is explained in the model by proposing that all the items in a visually-presented array are simultaneously registered in a Visual Information Store (VIS). VIS is similar in its properties to Broadbent's (1958) S system (Section 1.1.3) in that information is lost through decay in less than 2 seconds unless that information is recoded into a longer-lasting formal representation.



Visual Information Store
Auditory Information Store

Figure 1.3. Sperling's (1967) model for short-term memory. In Sperling's Model 3 a dotted arrow connects the Recognition Buffer to Scan, but, as no indication is given of its function, the arrow has been omitted here.

The recoding of VIS information occurs in two stages. First, there is a stage at which VIS is scanned and motor programs are set up in a Recognition Buffer. These programs constitute the neuro-muscular commands necessary for overt or subvocal pronunciation of the items presented, and can be established in parallel for several items in VIS. Second, the motor programs are activated one at a time, normally at a rate of 3-4 letters per second. This serial activation constitutes rehearsal, and its function is to transfer items into an Auditory Information Store (AIS) which receives input directly from the analysis of acoustic stimuli, as well as from the rehearsal of visual stimuli.

The interaction between a rapidly-decaying VIS store and a temporally-limited serial rehearsal process ensures that only a restricted number of items from a briefly-presented set can be reported. The contents of AIS can themselves be rehearsed by scanning, activation of motor programs, and overt or covert pronunciation. A response is made either by pronouncing the motor program aloud, or by conversion of the program into a complementary set of instructions for writing (this latter conversion being achieved by the Translator).

Two observations were crucial in determining the form of Sperling's (1967) model. The first was that subjects performing Sperling's experimental tasks tended to rehearse the letters silently or aloud before recalling them. This tendency to covert or overt articulation in short-term recall had been observed by Whitehead (1896) and many times since, and is incorporated in the model by the scanning and rehearsal processes.

The second crucial observation was that subjects made errors in which one of the letters presented in the stimulus array was replaced at recall by a similar-sounding letter to the one presented, despite the visual nature of the stimulus. Thus, a stimulus letter B might be replaced at recall by P, or T by D (Sperling, 1963). Apparently unknown to Sperling, both Smith (1895) and Watkins (1914) had commented on this effect of phonemic similarity in immediate recall. Conrad (1959, 1962) had coined the term "acoustic confusions" to describe the substitution of similar-sounding letters, even with visual presentation.

In Sperling's (1967) model, "acoustic" or "auditory confusions" occur in AIS. Information in AIS is prone to decay, and therefore it is conceivable that when recall is required, the information concerning a particular item has decayed partially but not completely. Attempts to reconstruct the item on the basis of partial information may result in a product which is similar to, but not identical with, the original stimulus. Sperling (1970) and Sperling and Speelman (1970) proposed that AIS stores phonemic information, whilst continuing to insist, "that rehearsed letters are remembered in the same memory as unrehearsed, acoustically-produced letters ... [and that] this memory is properly called auditory memory (or auditory information storage) because it depends critically on the sound of the stimuli" (Sperling and Speelman, 1970, pp.183-4).

Lastly, Sperling's (1967) model is purely a model for short-term memory; it makes no mention of how information is registered in Secondary Memory. However, Sperling (1970) remedied this situation by the unusual solution of having each short-term processing stage linked to its own distinct long-term store. Thus, VIS is connected to a visual secondary memory, the Recognition Buffer connects with a motor SM, and AIS connects with an auditory SM. The scan and rehearsal components are linked to inter-modality SMs which are equated with skills. Sperling does not indicate how semantic memory fits into this scheme, but it is certainly clear that some long-term trace will be formed for an item whatever stage of processing it has reached, and however many times it has or has not been rehearsed.

1.1.6. New models and new evidence.

The models of Broadbent (1958), Waugh and Norman (1965) and Sperling (1967) were only three of the many verbal and diagrammatic models of memory put forward (see Norman, 1970, for a representative sample). This proliferation of models was encouraged by the appearance of several new lines of evidence which were held to support the distinction between PM and SM. This extensive literature has been reviewed by several authors (e.g. Murdock, 1967; Broadbent, 1970, 1971; Baddeley, 1972; Wickelgren, 1973; Postman, 1975), and only the more important arguments will be discussed here.

(a) The Brown-Peterson paradigm.

Brown (1958) and Peterson and Peterson (1959) studied the effect of preventing rehearsal on the short-term retention of information. Peterson and Peterson (1959) presented subjects with 3 unrelated letters, followed by a 3-digit number. The subjects were required to count backwards by threes from the number given for a period of 0-18 seconds, and then attempt recall. Under these conditions, the proportions of sequences recalled perfectly, within 2.8 seconds from the recall cue, fell rapidly from 95% at 0 seconds delay, to 30% at 9 seconds, and then more slowly to 20% after 18 seconds. This finding was interpreted as indicating that the prevention of rehearsal by counting backwards causes decay of information in PM until, after a period of roughly 15-20 seconds, recall involves PM only.

There are two major problems in interpreting these results. First, the presence of interpolated activity confounds decay with interference effects, and other experimenters using different techniques have argued that interference, not decay, is the primary cause of loss of information in short-term memory. Second, Standing and Sampson (1971), and Johansson, Lindberg and Svensson (1974) have shown that the form of the retention curve obtained in the Brown-Peterson paradigm depends critically upon such factors as the modality of presentation, the memorization strategy of the subject, and the way in which the response sequences are scored. In general, a much flatter curve results from relaxing the requirement that letters must be recalled in the correct order in order to be scored as correct.

Thus, it is no longer clear just what information is lost by rehearsal prevention and at what rate. The paradigm can no longer be used as a line of evidence in favour of the separation of PM and SM.

(b) <u>Phonemic and semantic similarity effects: differential encoding in PM and SM.</u>

Waugh and Norman (1965) cited Sperling's (1963) claim, based on "acoustic confusion" errors, that PM was phonemic (acoustic) in nature. SM, in all accounts, holds semantic information. Both PM and SM contribute to short-term memory, whilst only SM is involved in genuinely long-term memory. Only SM has the capacity to learn.

Baddeley (1966a) showed that immediate recall of a sequence of unrelated words was adversely affected by phonemic similarity between them (e.g. mad, cat, map, mat, cap), but much less affected by semantic similarity (e.g. huge, big, great, wide, large). However, Baddeley (1966b) used the same materials in an experiment in which 10-word lists were presented four times to subjects to learn, with a task between each presentation to minimize rehearsal. Recall was tested after 20 minutes of delay filled with a digit span task. In this (SM) condition, the ability to recall the sequence correctly was impaired by semantic similarity, and not by phonemic similarity.

These two experiments (Baddeley, 1966, a, b), along with similar findings, were taken as evidence for predominantly phonemic coding in STM, and exclusively semantic coding (or associative coding) in LTM. This interpretation can be questioned (see Section 1.2. last paragraph), but accorded well with the predictions of the rapid-transit input model.

(c) The serial position curve: primacy and recency.

If a subject is presented with a long sequence of items which exceeds the memory span, and is asked to recall as many items as possible, then the probability of correctly recalling a particular item depends on its position in the list (Deese, 1957; Murdock, 1962). Typically, the first few items in the list are recalled well (the "primacy effect"), the middle items are recalled at a steady, low probability, and the probability of correct recall increases again over the last 5 or 6 items (the "recency effect"). Waugh and Norman (1965) proposed that the primacy effect, and the central, flat part of the curve represent the contribution of SM to free recall, whilst the rise in performance over the last few items (the recency effect) is due to those items being held in PM at the time of recall.

Evidence supporting this account came from a number of experiments in which factors which might reasonably be thought to influence PM were shown to affect the recency portion of the serial position curve, whilst other factors expected to influence SM were shown to affect the primacy portion of the curve (see Watkins, 1974). For example, Glanzer and Cunitz (1966) showed that when rehearsal was prevented, delayed recall of a list of words eliminated the recency effect whilst having little influence on the rest of the curve. On the other hand, varying the presentation rate (and hence reducing the amount of time available to learn each item) reduced the primacy and central portion of the curve whilst leaving the recency effect unchanged.

Following the success of experiments of this sort, the study of the recency effect came to be used as an alternative to memory span procedures for the interrogation of PM. Various formulae were proposed for devising the capacity of PM from recency data (e.g. Waugh and Norman, 1965; Baddeley, 1970).

Unfortunately for this clear picture, recent evidence has arisen which creates severe difficulties. Glanzer and Razel (1974) showed that the magnitude of the recency effect, and hence the estimated PM capacity, for a sequence of items was roughly the same whether those items were one or two syllable words, proverbs of more than 6 words, or unfamiliar sentences (hard to reconcile with a phonemic PM). Baddeley and Hitch (1975) have demonstrated recency effects in undoubtedly LTM recall (e.g. recall of a season's rugby games by members of the team), and also review experiments demonstrating differential effects of various factors (including articulatory suppression and concurrent memory load) on memory span and the recency effect. These results led Baddeley and Hitch, "to abandon our previous view that recency represents the output of a limited capacity short-term store ... [and] adopt in its place a view ... that the recency effect represents a retrieval strategy which relies heavily on ordinal retrieval cues". (Baddeley and Hitch, 1975, p.14).

The writer personally doubts whether a single unitary account can be given to cover all instances where remembering is better for things experienced relatively recently than for other, more distant, events. (cf. Morton, 1970, p.245, where a distinction is made between associative-semantic "finality effects" and acoustic-phonological "recency effects"). However, as this thesis is centrally concerned with the concept of a limited capacity, phonemic short-term store it will concentrate exclusively on memory span techniques, to the exclusion of the recency effect.

(d) Amnesic dissociation between PM and SM.

Returning to the evidence held to distinguish between PM and SM, mention must be made of the studies on amnesia.

Warrington (1971) reviews a number of such studies showing that amnesic patients who are grossly impaired on long-term memory tasks may nevertheless have perfectly normal memory spans. Conversely, a series of papers by Shallice and Warrington (e.g. Shallice and Warrington, 1970) have reported in detail upon a patient whose long-term memory was normal, but who was grossly impaired on short-term recall (e.g. a digit span of one or two items). Whilst this latter case raises problems for the input model (see Section 1.3.6.), taken with the amnesic findings it pointed to the existence of clinically-dissociable PM and SM stores.

1.2. SEMANTIC INFLUENCES IN SHORT-TERM MEMORY: THE ANATOMY OF A RED HERRING.

Attention was drawn in Section 1.1.4. to the dangers inherent in failing to distinguish clearly between PM and SM as hypothetical memory stores, and STM and LTM as experimental procedures. This warning was made by Waugh and Norman (1965, p.101) and repeated by several authors (e.g. Atkinson and Shiffrin, 1968; Morton, 1968; Baddeley and Patterson, 1971; Broadbent, 1971; Craik, 1971), but despite these cautions, numerous authors have used the terms PM and STM (and SM and LTM) interchangeably, with serious consequences. The worst effect of this confusion was the development of a belief that the input model held that short-term recall was mediated solely by phonemic coding and that semantic factors should only influence long-term recall.

Hebb (1961) presented a series of different lists of digits to subjects. Immediate recall was required for each list. Unknown to the subjects, the same list of digits was repeated at intervals throughout the experiment. Performance on that list improved throughout the course of the experiment, showing that a single presentation and recall of a list is sufficient to establish an enduring (SM) trace of that list.

The writer's introspection is that the meaning of a word is known as soon as that word is consciously perceived. Indeed, there is evidence that a word's meaning can influence behaviour when that word is exposed so briefly that the subject is unaware of its having occurred (Dixon, 1971; Allport, 1977; Marcel and Patterson, forthcoming). Certainly, subjects are able to categorise a pair of visually-presented words as belonging to the same or different semantic categories with reaction times from 430 to 720 milliseconds (Schaeffer and Wallace, 1970). Also, recoding strategies of the type described by Miller (1956 - see Section 1.2.2.) require knowledge which memory models would normally ascribe to SM.

Thus, it is not surprising that an assortment of factors that might loosely be termed "semantic" can be shown to affect short-term memory. Examples include:-

(a) Immediate recall of letter or word sequences improves as the sequences approximate more closely to normal English (Marks and Jack, 1952; Coleman, 1963; Baddeley, 1964, 1971).

(b) Digit sequences are better recalled in ~~their~~ an ascending order than in the descending order of presentation (Hinrichs and McKoon, 1973).

(c) If subjects are presented with 3 stimulus words, then a further 3 distractor words before recalling the stimulus words, the number of intrusion errors increases if the distractor words are semantically (or phonemically) similar to the stimulus words (Dale and Gregory, 1966).

(d) Instructions given to subjects can influence the relative emphasis placed upon phonemic or semantic encoding in a recall task, as revealed by the subsequent influence of phonemic and semantic factors on recall performance (Klein and Klein, 1974; Triesman and Tuxworth, 1974; Goldstein, 1975; Levy and Craik, 1975).

Numerous other studies could be cited (see Shulman, 1971, 1972; Postman, 1975). The central point at issue here, however, is the relevance of these findings to the theoretical issues to which they are supposedly addressed. If any input model of memory had seriously proposed that verbal information is <u>necessarily delayed</u> in a phonemic PM store before being transferred to a semantic SM store, then the discovery of semantic influences over short intervals of time would have been evidence against such a model. However, as emphasised earlier in Sections 1.1.4 and 1.1.5, neither Waugh and Norman (1965), nor Sperling (1967, 1970) incorporated such an obligatory delay feature. As Broadbent (1971, p.343) writes, "so far as is known, there exists no theorist who would contend that long-term memory plays no part in the short-term, and consequently demonstrations that the principles of long-term memory hold in short-term do not discriminate between theories."

The belief that demonstrating semantic influences in short-term memory disproves the rapid-transit input model is false, and arises purely through a failure to distinguish between PM and SM as <u>stores</u>, and STM and LTM as <u>procedures</u>.

Before leaving this issue, one more point is worth making. The presence of confusions within a particular modality or form of coding can legitimately be regarded as evidence for the operation of that modality or code under the particular conditions of the experiment. However, the <u>failure</u> to find confusion effects, (or, for that matter, to find improvement in performance) cannot be taken as evidence <u>against</u> the operation of a modality or code. Absence of confusion along a particular dimension is equally compatible with that dimension operating at a high, error-free level of efficiency under the conditions tested. This point has been made by Gruneberg and Sykes (1971) and by Morris (1977), and is well worth repeating.

1.3. GENUINE PROBLEMS FOR THE INPUT MODEL.

Figure 1.4 represents a generalised input model incorporating the crucial features of Broadbent (1958), Waugh and Norman (1965), Sperling (1967) and many similar models. Operations are performed on incoming spoken or written language to derive the phonemic representations of the stimulus items. These phonemic representations are stored in PM from whence they can be used to access their corresponding semantic representations in SM. The establishment of an SM trace is achieved automatically on the initial entry of an item into PM, and is repeated (or strengthened) by subsequent rehearsal, which also serves to maintain the trace-strength of the item in PM. Both PM and SM have access to the response-producing systems.

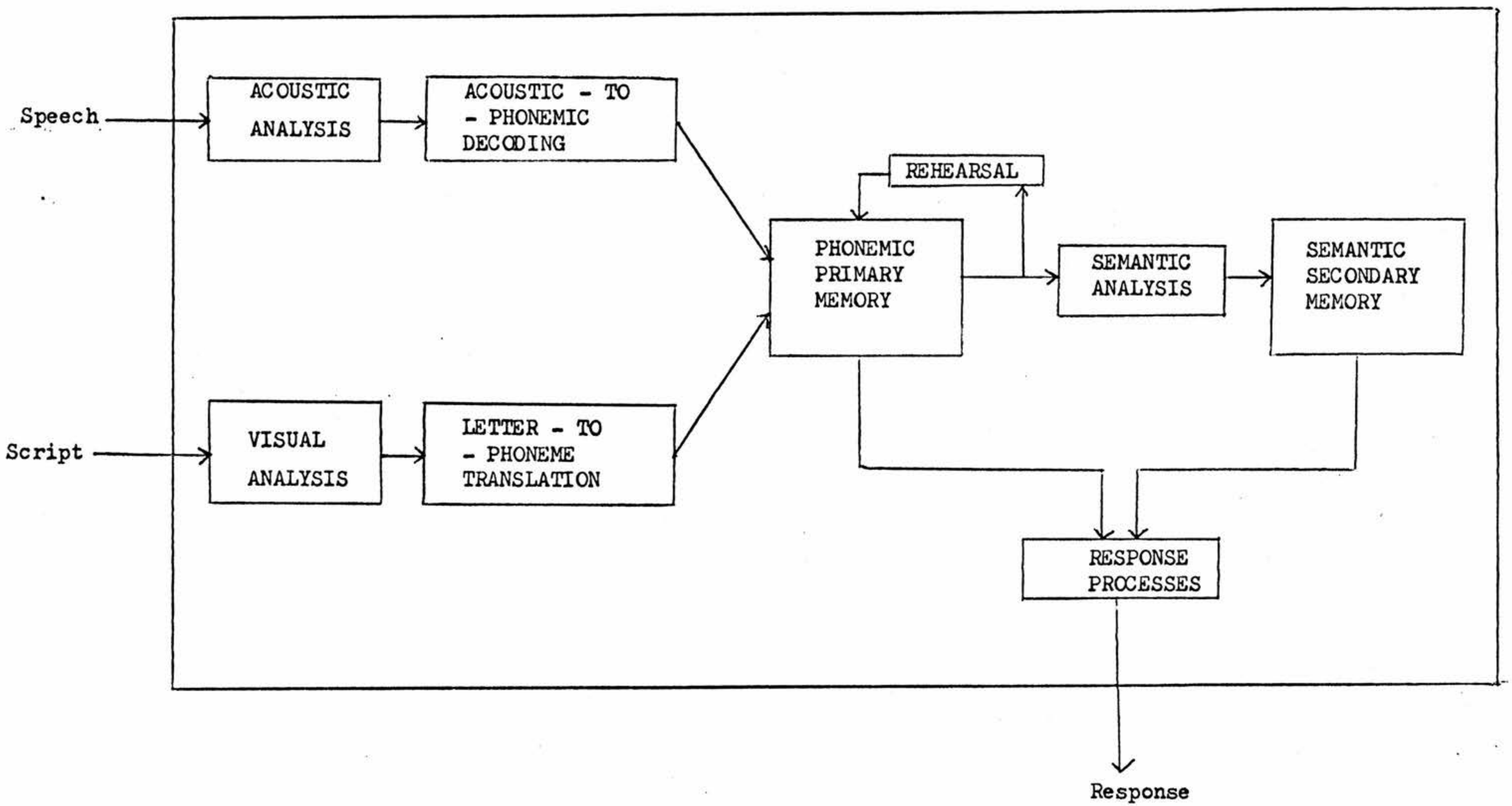
Sections 1.3.1. to 1.3.8. below will consider some of the major problems faced by this general model.

1.3.1. Phonemic Translation.

The generalized input model can be critized at several points as being incompletely specified. An example is the failure of theorists to give an account of the translation processes involved in obtaining a word's phonemic form from its written (or spoken) form.

In a discussion of automatic text-to-speech translation, Ainsworth (1975) discusses two alternative methods by which this conversion might be achieved. The first is a "dictionary method" whereby words are identified as wholes, and phoneme sequences are simply associated

Figure 4.1. A generalised 'input model' for memory.



with their appropriate dictionary units. This method is simple, but requires as many units as words to be read, and is therefore unable to cope with letter strings for which no established dictionary unit exists.

The second method utilizes the regularities to be found in spelling patterns and computes phonemic forms from a knowledge of letter-to-phoneme conversion rules. This method may be more economical, and is applicable to all encountered letter strings. However, the complexities and irregularities of English spelling create difficulties for this method, as examplified by the fact that one system for rule-governed reading of words taken from children's books achieved only 90% success after incorporating 166 correspondence rules (Berdiansky, Cronnel and Koehler, 1969). It seems plausible to suggest that any satisfactory model of word recognition must incorporate both dictionary units <u>and</u> conversion rules.

<u>1.3.2. Phonology and word recognition: I. Studies on normal readers.</u>

The role of phonology in reading is a matter of continuing debate (e.g. Marshall, 1976). This section will concentrate only on those observations which may be taken as contradicting the predictions of the input model.

Allport (1977) presented to subjects very brief exposures (50 to 100 msec.) of arrays of 2 to 4 words followed by a 'pattern mask' of jumbled letter-fragments. When subjects wrote down what they experienced, they made frequent "visual segmentation" errors (e.g. <u>cake</u> + <u>lawn</u> $\longrightarrow$ "lake"). Allport (1977) also reported semantic errors (e.g. <u>calf</u> $\rightarrow$ "lamb"; <u>pie</u> $\rightarrow$ "tart"), although doubt has been cast upon the statistical reliability of the semantic error rate obtained (Ellis and Marshall, 1978). In contrast, no errors occurred which were unequivocally phonological (this was also the experience of Ellis and Marshall), which Allport (1977) claims as evidence against a phonemic stage between visual and semantic analyses. However, although the discrepancy between the very frequent visual errors and the non-occurrence of phonological errors is striking, it was pointed out earlier (in Section 1.4.) that the absence of confusion at a particular level of analysis is compatible with operations at that level functioning in an efficient, error-free manner under the conditions examined.

Bower (1970) attempted to test the input model by use of the many-to-one nature of the correspondence between letters and vowels in Greek. Bower took a passage of Greek text, and substituted the 8 letters which correspond to the vowel /ee/ one for another, and similarly substituted the two /o/ vowels for each other. The input model was interpreted as predicting that there should be no difference between the times taken to read the normal and mutilated passages aloud, since the derivation of phonemic form from written form is supposedly independent of the particular orthographic means used to represent the phonemic sequence. Contrary to this prediction, skilled readers took 1½ times longer to read the mutilated passage aloud than to read the normal passage.

As a test of the input model, Bower's (1970) experiment is crucially dependent upon a conversion-by-rule interpretation of the early stages of the model. Even if this interpretation is accepted, Meyer, Schvaneveldt and Ruddy (1974) argue that the letter-to-phoneme conversion rules may be sensitive to the graphemic structure of letter sequences, and that this may be disrupted by Bower's procedure, resulting in slower performance.

An alternative explanation within the framework of the input model would supplement the conversion rules with dictionary units (see Section 1.3.1.). Such units, which recognize words as wholes , could operate in Bower's (1970) normal text condition, but would be inactivated in the mutilated text condition which would need to be read by the conversion rules (quite plausibly a slower process). This is the essence of Brown's (1970) criticism of Bower's (1970) test of the input model.

Experiments similar in reasoning to those of Bower (1970), but more to account for within the input model, were performed by Baron (1973). When subjects were required to decide whether or not short written phrases made sense they took no longer to reject phrases that <u>sounded</u> legitimate but were visually nonsense (e.g. <u>In the haul</u>; <u>He seas poorly</u>) than to reject phrases that were both visually and phonemically nonsense (e.g. <u>nut and bout</u>; <u>cone slot</u>). Now, the most naive version of the input model does not permit subjects to reject homophonic nonsense phrases like <u>In the haul</u>, since semantic decisions are based upon the phonemic form, not the visual form. More sophisticated versions would probably still predict a longer time to reject homophonic nonsense than "genuine" nonsense.

When Baron's (1973) subjects were instructed to make a "Yes" response to all phrases that <u>sounded sensible</u>, regardless of the spelling, they were still slower to accept (and made more errors on) the homophonic phrases than the phrases which were both orthographically and phonemically legitimate. This finding is similarly problematic for the input model.

<u>1.3.3. Phonology in word recognition: II. Deep dyslexia.</u>

"Deep dyslexia" is the term applied by Marshall and Newcombe (1973) to a particular type of reading disorder occurring in brain-damaged patients. Marshall (1976) summarizes the characteristics of the condition, which include the following "symptoms":-

(i) The subject is totally unable to pronounce nonsense letter strings (e.g. <u>blurg</u>, <u>genk</u>).

(ii) The subject cannot detect rhyming in visually- dissimilar pairs of words (e.g. <u>newt</u>, <u>mute</u>).

(iii) Unlike normal subjects, the time taken to reject a letter string as "not a word" is no longer for letter strings which are homophonic with real words (e.g. <u>frute</u>, <u>rair</u>) than for nonhomophonic strings (e.g. <u>brug</u>, <u>lail</u>).

(iv) Visual errors are common (e.g. <u>shallow</u> → "shadow": <u>mellow</u> → "melon").

(v) Semantic errors are also frequent (e.g. <u>drama</u> ⟶ "play": <u>sick</u> → "ill"). Occasional composite visual-semantic errors occur (e.g. <u>sympathy</u> → "orchestra").

(vi) Reading success varies with the grammatical class of the words attempted, being much better for "content words" (e.g. nouns, adjectives) than for "function words" (e.g. determiners, pronouns).

Symptoms (i) to (iii) all indicate a complete inability to derive the phonological form of words from their written configuration, and yet the deep dyslexic is still able to derive semantic representations of words, as attested by the frequent occurrence of semantic errors. In Marshall's (1976) words, "it is difficult to see how the patient who presented with <u>nice</u> produces the circumlocutory utterance 'Name ... in France ... South of France' ... could have arrived at a semantic reading via a phonological form which he so clearly fails to articulate." (Marshall, 1976, p. 114). Marshall also adds that the input model is embarrassed by the strong syntactic and semantic bias which is typically displayed in the reading performance of the deep dyslexic.

<u>1.3.4. Phonology in word recognition: III Word transitional probability and phoneme identification.</u>

Morton and Long (1976) presented to subjects sequences of words like <u>At the sink she washed a ____ , thinking of when she was younger.</u>

Subjects inserted the word plate into the gap much more frequently than the word pan. That is, plate has a high transitional probability in this context, and pan has a low transitional probability. When sentences of this sort were presented auditorily to subjects who were instructed to respond to particular phoneme targets in word-initial positions, the same phoneme targets contained in high transitional probability words were responded to significantly faster than those in low transitional probability words.

Morton and Long (1976) argue that only word identification, not phoneme identification, can be influenced by the essentially semantic variable of word transitional probability. It must be, then, that the identification of the target phoneme followed or competed with the word identification which was itself affected by the context. There is no facility for such a mechanism in the input model.

1.3.5. The absence of a cross-modal "suffix effect" in short-term memory.

When a list of items is presented for short-term recall, the last few items of this are better recalled if the list is presented auditorily than if it is presented visually (Morton, 1970, p. 220). This advantage disappears if a spoken suffix such as "zero" or "ah" follows the last item of the auditory list, but the advantage remains if the suffix is a non-speech sound such as a burst of noise (Morton, Crowder and Prussin, 1971). The advantage conferred upon the last few items by auditory presentation has been interpreted as consistent with those items being held in some form of auditory memory (termed Precategorical Acoustic Store, or PAS, by Crowder and Morton, 1969). The spoken suffix displaces the contents of PAS, hence reducing the level of recall for auditorily-presented items to that found with visual presentation.

In Sperling's (1967) version of the input model, acoustic information is held in an Auditory Information Store (AIS) similar in properties to PAS. However, in Sperling's (1967) model (see Section 1.1.5), visually-presented verbal material is also converted into an auditory form and stored in AIS. Thus, Morton and Holloway (1970) argued that a visual suffix should be converted into an auditory form and hence reduce recall for the most recent items in an auditory sequence. This prediction from Sperling's model was not confirmed: the "suffix effect" was found neither with auditory presentation and a visual suffix, nor with visual presentation and an auditory suffix (Morton and Holloway, 1970).

1.3.6. Selective impairment of PM.

In a series of papers by Warrington and Shallice (1969, 1972), Warrington, Logue and Pratt (1971), and Shallice and Warrington (1970, 1974), a clinical patient (K. F.) has been described with an apparently selective impairment of primary memory. K.F.'s digit span with auditory presentation is limited to 1 or 2 items (Warrington and Shallice, 1969). Performance in short-term recall is generally better with visual than with auditory presentation (Warrington and Shallice (1969, 1972), but K.F.'s failure to recall more than 4 out of 80 visually-presented strings of 4 digits (or 0 out of 80 4-letter strings - Warrington and Shallice, 1969), renders Wickelgren's (1973) dismissal of the deficit as "modality-specific" implausible.

K.F.'s short-term memory for meaningful environmental sounds (cat mewing, telephone ringing, etc.) is perfectly normal, supporting the general proposal that PM, however, it is to be characterized, is a verbal store (Shallice and Warrington, 1974). Furthermore K.F. performs normally on a variety of tests of secondary memory such as learning 10-word lists, recalling short stories, or learning lists of paired-associate words (Warrington and Shallice, 1969: Warrington, Logue and Pratt, 1971).

On the input model, a PM store reduced incapacity to only one or two items, as K.F.'s appears to be, would still be able to transfer items through to SM. However, as Shallice and Warrington (1970) argue, such a restricted PM ought to produce some measurable deficit in rate or efficiency of learning, and yet attempts to discover such a deficit have failed to date.

<u>1.3.7. Phonemic effects in long-term memory.</u>

When speakers are almost, but not quite, able to recall a familiar word, they may be said to be in a "tip-of-the-tongue" state. In this condition, subjects can often provide words that are either semantically or phonemically similar to the desired word (Brown and McNeill, 1966). Also, lexical errors in spontaneous speech - where a speaker produces a different word from that intended - may be either semantically or phonologically similar to the intended word (Tweney, Tkacz and Zaruba, 1975). These two observations constitute <u>prima facie</u> evidence for the involvement of phonemic as well as semantic factors in long-term memory.

Further evidence for phonemic effects in long-term memory can be found in experiments by Gruneberg and Sykes (1969), and Gruneberg, Colwill, Winfrow and Woods (1970). In one experiment by Gruneberg <u>et al</u> (1970), subjects were twice shown a sequence of 20 nonsense syllables, using visual presentation at 4 seconds per syllable. The following day (10-12 hours later) the subjects were asked to rate the syllables of a 30-item test list as either "old" (i.e. in the list from the day before) or "new". New words which were phonemically similar to words from the original stimulus sequence were falsely categorized as "old" significantly more often than phonemically dissimilar test words.

As commonly formulated, the input model has no facility for the long-term storage of phonemic information.

1.3.8. Input and immunization: a caution.

Sections 1.3.1. to 1.3.7. present real difficulties for the input model, particularly in its claim that incoming visual information must invariably be recoded into phonemic form before its semantic representation can be accessed. However, no single objection to the model is insuperable, for reasons that have to do with the logical and scientific status of functional models.

A model, as Broadbent (1957) noted, is essentially a verbal theory in diagrammatic form. Models, like theories, generate predictions which may be tested and found wanting. However, a particular experiment can only test predictions from one small part of a complex model, and it is always possible to modify the model in some *post hoc*, and non-drastic manner to take account of the new finding. Popper (1976) has adopted the term "immunization" to describe this procedure by which a theory can evade falsification indefinitely through cumulative minor modifications.

There is no clear dividing line between theory improvement and theory immunisation. The decision to abandon one account and adopt another may be based on parsimony, increased generality and information content in the new theory, on a belief that the old theory has become too arbitrary in its attempts to "explain" problematic data, or on any combination of these and other factors. With this in mind, Chapter 2 will present an alternative model for memory and verbal behaviour which, in the writer's opinion, is an improvement upon the input model in some of the ways just mentioned.

<u>SUMMARY.</u>

(1). Early accounts of the memory span regarded it as a measure of the mind's capacity to "take in" information.

(2). This view was reinforced in the development of an 'information-processing' view of short-term memory, and was incorporated into a succession of diagrammatic models of human memory. Three of these are described in detail (Broadbent, 1958; Waugh and Norman, 1965; Sperling, 1967).

(3). Evidence held to support the distinction, made by the input model, between a phonemic <u>Primary Memory</u> and a semantic <u>Secondary Memory</u> is discussed.

(4). Several lines of evidence held to contradict the general input model are also discussed, and a final observation on the non-falsifiability of functional models is included.

CHAPTER 2: THE LOGOGEN MODEL IN SPEECH AND SHORT-TERM MEMORY, THE ERROR EQUIVALENCE HYPOTHESIS, AND THE FORMS OF PHONEMIC SPEECH ERROR.

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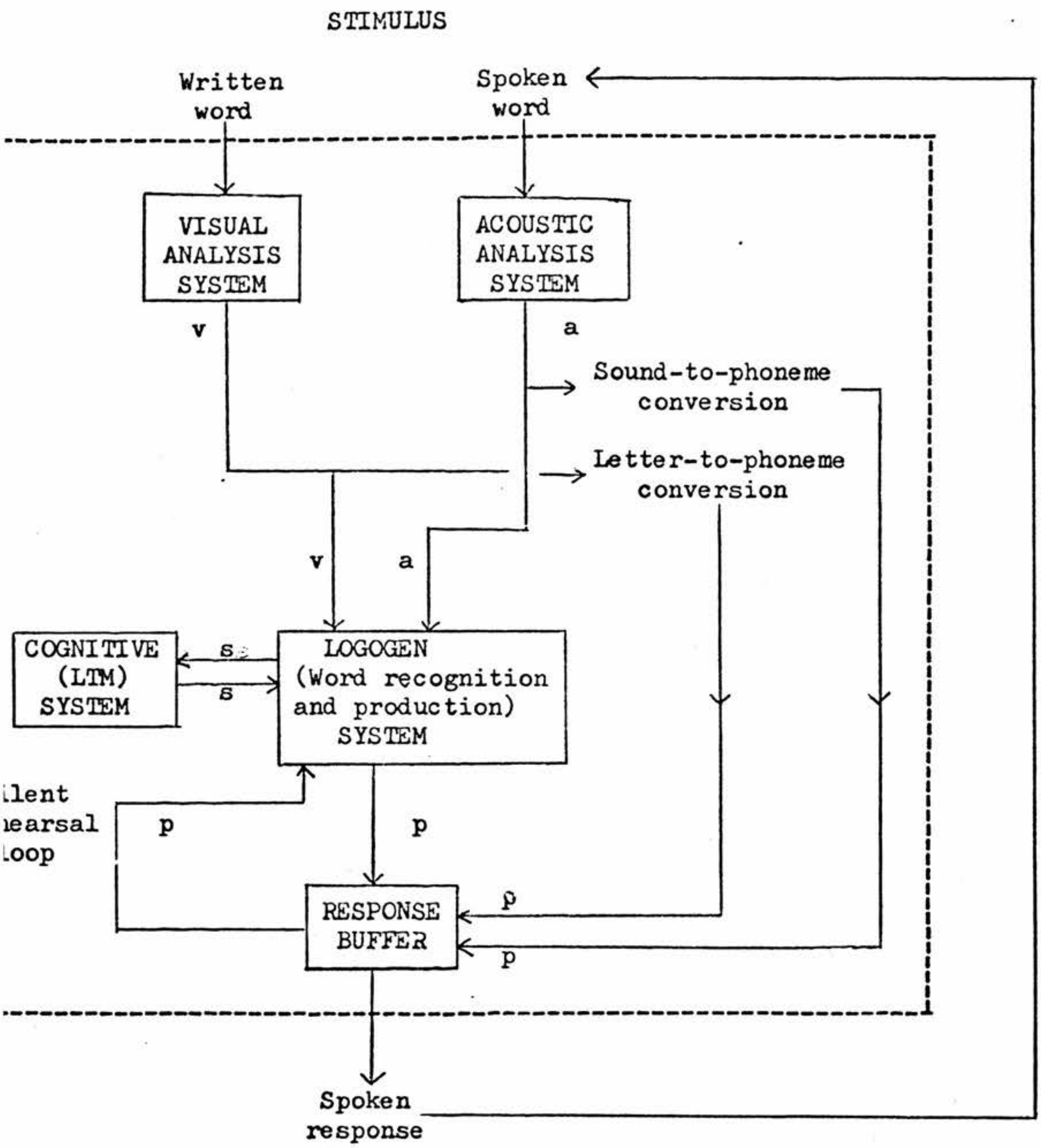
2.1. THE LOGOGEN MODEL.

This first section of Chapter 2 is devoted to a fairly complete exposition of a model for memory and language behaviour developed over the years in a series of papers by Morton (1964a, 1968, 1970) and Morton and Smith (1974). Additional relevant applications of the model (called the Logogen Model) can be found in Morton (1969), Crowder and Morton (1969), and Morton and Long (1976). During the course of the exposition, references will not be given in support of every single point made. The reader can assume that all the points made are taken directly from one or other of the above papers except when comments are enclosed within square brackets, which are reserved for the writer's own interspersed remarks.

2.1.1. An outline of the Logogen Model.

At the centre of the Logogen Model (Fig. 2.1.) is the Logogen System itself, which is made up of a collection of individual units called logogens. It is supposed that each word (or, more properly, morpheme) in the vocabulary is represented by a different logogen. Logogens act as transducers between different kinds of coding. Each logogen receives inputs from other parts of the model, these inputs being indicators of the presence of information which is relevant to the production or recognition of the word which that logogen represents. The occurrence of a word as an external visual or acoustic stimulus will be signalled to the appropriate logogen by the Visual Analysis System and the Acoustic Analysis System respectively.

A logogen is essentially a counting device. As information pertaining to the visual or acoustic occurrence of a word increases,



a = acoustic code
p = phonemic code
s = semantic code
v = visual code

ure 2.1 The Logogen Model for language and memory (based on
ton, 1968; 1969, and Morton and Smith, 1974).

the 'level of activity' within the corresponding logogen also increases. When a first critical threshold of activity is exceeded within the logogen, a (semantic) code is sent to the <u>Cognitive System</u> indicating the occurrence of the word presented, and allowing its semantic representation to be accessed. At a fractionally higher level of activity in the logogen, induced by additional pertinent information, a second threshold is exceeded, causing, on this occasion, a phonemic code to be made available. This phonemic code constitutes a potential verbal response: it is stored in the <u>Response Buffer</u> from which it may be converted into an overt response, although this is not necessary.

The Cognitive System is the locus of all semantic, syntactic and associative processes within the model, and is equivalent in this respect to the Secondary Memory stores of many other models (see Sections 1.1.3. to 1.1.6.). The recognition of a word can be facilitated by the Cognitive System if contextual information indicates that that particular word is likely to occur. This facilitation is achieved by the Cognitive System transmitting the semantic code to the logogen which increases the level of activity, thus requiring less stimulus information to cause it to fire again. [With very strong context, the semantic code alone may provide enough information to exceed the threshold at which the phonemic (output) code becomes available (e.g. <u>If you go down in the woods today, you're sure of a big - - - -</u>). This, of course, is the normal process in spontaneous, stimulus-free, speech production].

The Response Buffer holds phonemic sequences produced as output by the Logogen System. Silent rehearsal is envisaged as the re-circulation of items from the Response Buffer to the Logogen System and back to the Response Buffer until such time as an overt response is required, or rehearsal is terminated.

A given logogen unit can, then, be defined in terms of its inputs and outputs. There are two outputs: a set of semantic attributes and a phonemic sequence. The semantic and phonemic codes can also act as a source of input to the logogen: the former as contextual information in recognition or as input during spontaneous production, and the latter in rehearsal [and also, possibly, in "inner speech" and "phonic" reading]. The visual code and the acoustic code act as two additional sources of input, making four input codes in all. Different logogens are able to receive inputs in parallel, and hence can produce semantic attributes for more than one stimulus word at a time. Limits of <u>processing rate</u> for words are attributed to the Cognitive System. There is no limited-capacity processing channel for stimulus information prior to the Logogen System.

The Logogen Model has been applied to reading and word recognition (Morton, 1964a, 1968, 1969), to verbal short-term memory (Morton, 1968, 1970), to speech perception and production (Morton, 1968: Morton and Chambers, 1976: Morton and Long, 1976), to phonological development in children (Morton and Smith, 1974), as well as to the 'higher' syntactic and semantic aspects of language processing (Morton, 1968). However, it is the application of the Logogen Model to speech production and short-term memory which is the central concern here. (The process of reading will also be considered). In particular, the functional unit of the Response Buffer will be focussed upon, and the next three sections are given over to a detailed description of the structure and function of the Response Buffer within the Logogen Model.

2.1.2. The role of the Response Buffer in the Logogen Model.

As a functional entity, the Response Buffer was first postulated to account for the phenomenom of the "eye-voice span" in reading (Morton, 1964a, b). When reading connected prose aloud, the eyes may be fixating a point on the printed line which is up to four or five words ahead of the particular word the reader is speaking at that moment. One of the forms of error which occurs during reading is the production of a word, or part of a word, before it is due in the sequence. Morton (1964b) gives the following example of a word being spoken too early in a sequence[1]:

led to a path beside him $\longrightarrow$ led him to a path beside him

Now, in order for a word to be anticipated and spoken out of its turn, it must have been one of the words within the eye-voice span. That is, the word from within the eye-voice span must have been available as a potential response at the point in time when it intruded as an error. This is handled within the model by proposing that all the material within the eye-voice span has been visually analysed, has been passed to the Cognitive System via the Logogen System, has been made available as a potential response through the output side of the Logogen System, and is held in the Response Buffer from which an item may inadvertently be produced as a response before or after its correct position in the sequence. This account also explains the analogous "ear-voice span" in shadowing auditorily-presented material (Treisman and Geffin, 1967).

1 In this, and all subsequent examples, the correct (intended) form is given to the left of the arrow and the incorrect (error) form is given to the right of the arrow.

In the same study of reading errors, Morton (1964b) noted errors involving the substitution of words in the response which were functionally-equivalent synonyms (or antonyms) of words in the text, (e.g. most → many, Sunday → Saturday, evening → morning). The syntactic and semantic errors suggested that, "while reading aloud, the linguistic structure of the material was analyzed completely and then resynthesized before output" (Morton, 1970, p. 214). This provided the initial motive for suggesting that the semantic output from the logogen to the Cognitive System occurred before the phonemic output to the Response Buffer. Such a suggestion, when incorporated into the model, turns out to have additional explanatory power, including giving a potential account of the findings on subliminal perception, and on the condition of "deep dyslexia" mentioned in Section 1.3.3. (Morton, 1970, p.215) . The additional postulate required for these accounts to work is that the subjective experience of perceiving a stimulus word is contingent upon a potential response to that word being available as a phonological sequence in the Response Buffer along with information that a stimulus has been processed by the sensory analysis systems (Morton, 1964, 1968, 1970). [This carries the interesting implication that all activity in the Cognitive System is unconscious (or preconscious) and that the processes within that system are only made conscious through their phonemic products becoming available in the Response Buffer.]

On the question of the nature of the coding within the Response Buffer, Morton and Smith (1974, pp. 164-5) write, "Although there is no prior evidence which would motivate a precise assignment of the level of this code, there are reasons in terms of the internal consistency of the model which lead to the suggestion that the code is phonemic rather than phonetic. Thus, at this point in the model [i.e. at the Response Buffer], "pit" would be represented as /pit/ and "spit" as /spit/ rather than the phonetic forms [p^hit] and [sp$^=$it] respectively, where [p^h] and [$p^=$] represent the aspirated and unaspirated forms of /p/. In the interests of economy of coding the specification of such allophonic variants would be left to later stages as would such aspects of speech as elisions between words and suprasegmental features such as intonation and stress assignment."

As a source of phonemic responses, the Logogen System can only operate upon stimuli for which an appropriate logogen exists; that is, for words already in the vocabulary. However, as Morton and Smith (1974) point out, some account is needed for our obvious ability to mimic, or to read aloud, nonsense syllables which have no corresponding logogen. This is achieved by introducing into the model additional pathways which connect the sensory analysis systems to the Response Buffer, by-passing the Logogen System.

Mimicking an auditorily-presented nonsense syllable requires the operation of rules on the by-pass pathway which convert the acoustic code into a phonemic code. The precise nature of the acoustic code is not specified, but Morton (1968) states that it does not contain symbols which could be given a phonetic realization, nor could it be characterized as a "distinctive feature matrix." This, however, does not preclude the possibility of a one-to-one mapping of some features of the acoustic code on to a phonemic code which could be entered into the Response Buffer and outputted as an imitative response.

[To read a visually-presented nonsense syllable, letter-to-phoneme conversion rules are required. These will operate on the visual code (i.e. the output of the Visual Analysis System) and seek a rule-governed conversion of the letter sequence into a phoneme sequence. The phoneme sequence will then become available to the Response Buffer from which it can be uttered as a spoken response, or presented to the Logogen System via the rehearsal loop. This latter procedure enables the Cognitive System to "understand" a visually-unfamiliar written word whose phonemic sequence (or acoustic form if the word is read aloud) is, however, familiar. It will be appreciated that the combination of logogens working on whole-word analysis, plus letter-to-phoneme conversion rules, provides the two modes of deriving the meaning of a written word (visual and phonological) required by the considerations of normal and "deep dyslexic" readers in Sections 1.3.2. and 1.3.3. Given that the logogens also act as sources of phonemic forms, the logogens plus rules correspond to the dictionary and conversion rule methods of obtaining phonemic forms from written forms which were discussed in Section 1.3.1.].

Within the model, all decisions pertaining to the phonemic form of visual or acoustic verbal stimuli are made at the level of the Response Buffer. Thus, acoustically-presented words will be recognized by the Logogen System before their phonemic form can be analyzed at the Response Buffer. This permits explanation of Morton and Long's (1976) finding that the contextual influence of word transitional probability influenced the speed of identification of phoneme targets in auditory word sequences. (See Section 1.3.4.). [Decisions as to the phonemic form of nonword verbal stimuli must, on this account, be made after the operation of the conversion rules which derive a phonemic code from the visual or acoustic code].

2.1.3. The Response Buffer in short-term memory.

The properties with which the Response Buffer must be credited in order to explain the observations on the eye- and ear-voice spans Section 2.1.2.) turn out to be much the same properties as are normally attributed to Primary Memory stores in standard models of memory (cf. Sections 1.1.3. to 1.1.5.). Morton (1970, p.238) lists these properties, which are the same as those of the Memory Buffer in Atkinson and Shiffrin's (1965) model, as:-

(1). The buffer has a limited capacity of items (estimated at 4 or 5).

(2). Items in the buffer are stored temporally.

(3). After the buffer has been filled it stays filled as long as the subject is paying attention (to its contents).

(4). Each entering item bumps out an old item.

(5). Items are always encoded correctly when initially placed in the buffer, (as long as inputs are not too fast).

[Morton (1970) also quotes Atkinson and Shiffrin's (1965) requirement that items still in the buffer at the time of test are recalled perfectly, but this is contradicted by the further claim that phonemic confusion errors arise at the level of the Response Buffer - see Section 2.1.4. below].

The important difference between the Response Buffer and PM in the input models has to do with the locus of the two stores in their respective systems. In the input model, Primary Memory comes before Secondary Memory in the flow of information. In the Logogen Model, the Response Buffer in certain respects follows the Cognitive System. Thus, the Response Buffer is active in spontaneous (non-stimulus bound) production of speech, as well as in reading, shadowing, and short-term memory.

Given that all items for which there is an appropriate logogen (and this includes letters and digits) will, in the course of a short-term memory experiment, be registered by the Cognitive System before entering the Response Buffer, it is expected that semantic factors will be utilized wherever possible to assist recall. Hence, the demonstrations of semantic influences in short-term memory (Section 1.2.) are no more problematic for the Logogen Model than they are for the (rapid-transit) input model. Short-term recall will involve, in varying degrees depending upon the experimental conditions employed, the Cognitive System, the Response Buffer, the short-lived Precategorical Acoustic Store which is associated with the Auditory Analysis System (cf. Section 1.3.5.), and possibly even the very short-lived Iconic Memory associated with the Visual Analysis System (equivalent to Sperling's, 1967, "Visual Information Store" - see Section 1.1.5.). The ability of the Response Buffer, PAS, and Iconic Memory to act as memory stores is, in a sense, a secondary effect of their main functions within the model: only the Cognitive System is a genuinely specialized memory store, and even here this is but one aspect of its role as semantic and syntactic processor.

2.1.4. The Response Buffer as the locus of phonemic confusions.

In Section 1.1.5. of the previous Chapter, mention was made of the observations by Conrad (1959, 1962) and Sperling (1963) that, even with visual presentation, the errors that occur in short-term recall of disconnected items tend to involve the substitution, one for another, of similar-sounding items (e.g. B for P, or T for D in recall of letter strings). Conrad (1962, 1964) observed that the pattern of errors obtained in this way is similar to that obtained when listeners misidentify letters presented acoustically in a background of white noise, and so he termed the short-term memory errors "acoustic confusions". This term accorded with Sperling's (1967) concept of an Auditory Information Store in which these confusion errors arise, visual input being converted into an auditory/acoustic form by rehearsal (Section 1.1.5.).

In the Logogen Model, the responsibility for phonemic coding lies with the Response Buffer. Although acoustic perceptual errors could arise in the Acoustic Analysis System, the only locus for phonemic short-term memory errors, particularly with visual presentation, is the Response Buffer. It has been assumed (Section 2.1.2.) that material in the Response Buffer is coded in some phonological form, and hence the possibility arises of confusion errors, either in the course of silent rehearsal or at output (Morton, 1970, p.239). Morton (1964a, 1968, 1970) proposes that these errors would be better termed "articulatory confusions" than Conrad's (1959, 1964) description of them as "acoustic confusions". The correlation between articulatory confusions and genuinely perceptual acoustic errors is explained by reference to the close correlation between articulatory and acoustic similarity: that is, items which are pronounced in similar ways will also tend to sound similar.

Hintzman (1965, 1967) claimed to have produced evidence supporting the articulatory interpretation of confusion errors over the acoustic interpretation. In particular, Hintzman (1967) observed that in recall of visually-presented sequences of nonsense syllables, errors of place of articulation were common (e.g. reporting B for D or P for T), whereas errors of voicing (e.g. P for B) were less common. Hintzman pointed out that the reverse was the case in the auditory-perceptual confusions reported by Miller and Nicely (1955) and Conrad (1962) and thus claimed that different processes were responsible for the confusion errors observed in the two different situations. As an alternative to the acoustic theory, Hintzman (1965, 1967) proposed that short-term recall confusions are really kinaesthetic confusions, arising from similar muscular feedback patterns produced by subvocal rehearsal. This is different from the Logogen Model account, where "articulatory ilarity" refers to a more abstract phonemic similarity related to ilarity of the speech-motor programs necessary to execute production the items (Stockdale, 1971).

Wickelgren (1969) and Morton (1970) have argued that Hintzman's 65, 1967) results do not unequivocally support his case. Morton (1970) serves that the auditory-perceptual errors were obtained using a kground of white noise, and that it is possible to obtain different terns of perceptual confusion using noise with different characteristics. supporter of Sperling's (1967) or Conrad's (1964) account of recall fusions as occurring in an auditory store could "explain" Hintzman's a by arguing that decay or noise in the store is non-random .e. non-"white").

[Although the term "articulatory confusion" is closer in spirit n "acoustic confusion" to the Logogen Model account of these errors, terms "phonemic confusion" and "phonemic similarity" will be ferred here. These terms are equally compatible with the Logogen lel whilst being more neutral with respect to the rival accounts which is the aim of this thesis to distinguish between].

2. THE RESPONSE BUFFER IN SPONTANEOUS SPEECH.

Morton (1970, p.239) claims that, "The Response Buffer is seen having the primary function of allowing the production of speech to programmed efficiently." However, this aspect of the Response Buffer's action has not been explored in any detail by Morton. As presently nstituted, the Response Buffer can hold, simultaneously and in onological form, sequences of four or five words made available by the gogen System. The next two sections will examine the evidence which n be taken as indicating that phonological preplanning does indeed cur in the course of speech production, and that an entity with the properties of the Response Buffer is needed to account for these observations.

2.2.1. Phonological preplanning in speech: I. Co-articulation, vowel harmony, and segmental durations.

It is possible to conceive of speech production systems in which the actual phonological forms of to-be-spoken items only become available one syllable, or one word at a time. Indeed, a one-phoneme-at-a-time system is, in principle, possible. Demonstrating that the human speech production system incorporates larger-scale phonological preplanning involves producing evidence that articulation at a time _t_ can be influenced by as-yet-unspoken phonological segments.

One such line of evidence comes from the study of forward (right-to-left) co-articulation in speech, that is the adoption of postures by the articulatory organs which are accommodated to forthcoming consonants or vowels, rather than to the particular segments being currently spoken. For example, anticipatory lip rounding for the /u/ in _stew_ (/stu/) can begin during the /s/, two segments ahead of the point in time when the lip rounding is necessary. Co-articulation can take place across conventional syllable boundaries, thus indicating the temporal co-existence of more than one phonological syllable (MacNeilage, 1972; Nooteboom, 1972). The most extensive case of forward co-articulation known to the writer is the case of anticipatory lip protusion for the rounded vowel /y/ in the French sequence /istrstry/ which may begin during the first consonant in a sequence of an unrounded vowel, six consonants, and a rounded vowel, that is, six segments before the pronunciation of the rounded vowel (Benguerel and Cowan, 1974).

Fromkin (1966) cites anticipatory phenomena in vowel harmony languages as evidence for phonological preplanning. For example, in the Twi language, the quality of the vowel in a prefixed personal pronoun is determined by the vowel in the verb stem; [mɪdɪ] 'I cause' as opposed to [midi] 'I eat'. Fromkin states the vowel harmony may occur over stretches involving more than one morpheme, but does not state in detail the extent of the spans involved.

It has been known for some time that speech segment durations are systematically affected by their position in an utterance. Cohen and Nooteboom (1975) review data obtained by De Rooij indicating that vowel segment duration in phrase-initial words is reduced in proportion to the amount of speech material remaining to be produced, with this anticipation extending over at least 4 or 5 syllables.

Co-articulation, vowel harmony and anticipatory segmental duration effects differ in the estimates they provide of the extent of phonological preplanning. Co-articulation is the only one which has been studied in any depth from this viewpoint, and here the effects only range over 2 to 3 syllables at most - not a span which would demand the postulation of a Response Buffer of the sort described above. Much larger estimates of phonological span are obtained by considering the evidence of a particular form of phonological speech error, termed the Spoonerism.

2.2.2. Phonological preplanning in speech: II. The Spoonerism.

Speech errors, or 'slips of the tongue' are by no means infrequent occurrences in everyday speech, and they have recently been extensively exploited for the insights they can provide into the manner by which speech is organized and produced (e.g. Fromkin, 1973a). One of the commonest forms of speech error is the Spoonerism, which takes its name from the Reverend William A. Spooner (1844-1930), erstwhile Dean and Warden of New College, Oxford, who was reputedly responsible for such errors as:-

Wasted the whole term → Tasted the whole worm

You have missed all my history lectures. → You have hissed all my mystery lectures.

It is not at all certain how many errors attributed to the Reverend Spooner were actually made by him (Potter, 1976), but the name Spoonerism has come to refer to any slip involving the misplacement of consonants or vowels.

Spoonerisms provide one of the clearest pieces of evidence that stretches of speech longer than single words are planned in advance and held in some pre-articulatory form. The logic of this argument is exactly the same as the logic behind the proposal that the material within the eye-voice span must be stored as potential responses (Section 2.1.2.), and can be explained with reference to the following example, taken from Appendix to Fromkin (1973a):-

With this ring I thee wed → With this wing I thee red

The intended utterance has been distorted in production by a reversal of the consonants /r/ and /w/. That is, at the point in time when the speaker was attempting to speak the word 'ring' the initial consonant of the word was replaced by the initial consonant of 'wed' producing the error "wing". Now, in order for interference to have come from the word 'wed', that word must have been available in a phonological form as a potential verbal response.

The account of the theories of Meringer and Mayer (1895) given by Freud in The Psychopathology of Everyday Life states that, "When we innervate the first sound in a word or the first word in a sentence, the excitatory process already extends to the later sounds and the following words and in so far as these innervations are simultaneous with one another they can exercise a modifying influence on one another", (Freud, 1975, p.95). Similar statements can be found in Bawden (1900) and Jastrow (1906), but the modern interest in Spoonerisms as indicators of preplanning is usually traced to Lashley's (1951) celebrated paper on 'The Problem of Serial Order in Behaviour'. Lashley (1951) regarded Spoonerisms as evidence that an "aggregate of word units is partially activated or readied" prior to its internal or overt enunciation, and this argument has been repeated by a number of authors since (e.g. Fromkin, 1973a, several papers; Garrett, 1975).

It is possible to obtain an estimate of the maximum extent of phonological preplanning by examining the maximum range which anticipatory phonemic errors can cover. This was done for a corpus of German and Dutch Spoonerisms by Cohen (1966), Nooteboom (1967, 1969) and Cohen and Nooteboom (1975). It was found that the frequency of anticipatory phoneme errors decreased as the distance between the interacting phonemes increased, and that no phonemic errors spanned a distance greater than 7-9 syllables. As these authors remark, this estimate of preplanning is comparable with memory span capacities (Miller, 1956).

Several authors have pointed out that if phonological preplanning occurs, some form of memory store is needed to hold an utterance in the interval between planning and execution (e.g. Fromkin, 1966; Mackay, 1970; Shaffer, 1976). Baars and Motley (1974) refer to this store as the "output short-term memory", but appear to distinguish this from the "input buffer" investigated by standard short-term memory procedures. In terms of the Logogen Model being developed here, the task of storing stretches of preplanned, phonologically-coded speech would be assigned to the Response Buffer.

This would require the Response Buffer to be capable of holding simultaneous information concerning 7-9 syllables, which exceeds Morton's (1970) estimate of 4-5 'items' although this latter estimate is not based on any explicit data and the nature of the 'items' concerned is undetermined (4-5 disyllabic words equals 7-9 syllables).

Morton and Smith's (1974) suggestion that coding in the Response Buffer is phonemic rather than phonetic is also compatible with observations on Spoonerisms. Transposed segments in speech errors do not carry with them the properties distinctive to their original context, but are accommodated and co-articulated to their new contexts (Boomer and Laver, 1968; Fromkin, 1971; Nooteboom, 1972; Fodor, Bever and Garrett, 1974). This is most easily interpreted in terms of a model in which phonemes are transposed prior to the application of morphophonemic, phonological and co-articulatory rules and procedures (c.f. Morton and Smith, 1974). Fromkin (1973b) also makes a case for the "psychological reality of phonemes" by considering, "sounds such as those represented by the 'ch' in 'church' and the 'j' in 'judge' [which] are clusters of two consonants on the phonetic level ... [although] linguists have posited that in words such as 'choose', 'church', 'chain', and 'judge' these phonetic clusters are single phonemes. The fact that 'ch' and 'j' sounds in such words are never split in speech errors, although other consonant clusters such as 'sp' and 'gl' are, bears out this analysis."

2.3. THE TONE-GROUP AS OUTPUT FROM THE RESPONSE BUFFER.

If the Response Buffer stores impending stretches of speech in phonological form, then there are a number of ways in which it could operate. One possibility is that the Response Buffer "fills up" with a phonological sequence which is then "read out" of the buffer to lower stages of the production mechanisms before the buffer is refilled. On this mode of operation, the case arises that successive outputs of the Response Buffer might be marked in the stream of speech. To identify a likely candidate for such a role it is necessary to return once more to a consideration of the Spoonerism.

Two studies have examined Spoonerisms in relation to their distribution within the higher-order phonological unit of the "tone-group" (Halliday, 1963), or "phonemic clause" (Trager and Smith, 1951). Laver (1970, p.68-9) provides the following description:-

"The tone-group is a stretch of speech which lasts, on average, for about seven or eight syllables, and which contains only one very prominent syllable, on which a major change of pitch occurs in intonation. This prominent syllable ... [referred to] as the 'tonic syllable', is usually located at or near the end of the tone-group; as in Ask them to come into the GARden. The tone-group is also characterized by pauses which are usually optional but sometimes mandatory, at its boundaries.... The boundaries of the tone-group often, though not always, coincide with those of the syntactic clause. Lastly, the tone-group is the major unit for carrying intonation patterns, and has a simple correspondence with units of rhythm."

Boomer and Laver (1968) examined the distribution of Spoonerisms with respect to tone-group boundaries and reported that Spoonerisms almost always occur within tone-groups (the few phoneme transpositions which occurred between adjacent tone-groups involved phonemes from their respective tonic syllables). Similarly, out of 172 consonant and vowel Spoonerisms analyzed by Garrett and Shattuck (1974, as cited in Fodor, Bever and Garrett, 1974, ch.7), only two examples involved transpositions across phonemic clause (tone-group) boundaries.

Boomer and Laver (1968) compare the tone-group to Lashley's (1951) "aggregate of word units", and proposed that, "the tone-group is handled in the central nervous system as a unitary behavioural act, and the neural correlates of the separate elements are assembled and partially activated, or 'primed' before the performance of the utterance begins." In terms of the Logogen Model, this assembly of partially-activated elements would be stored in the Response Buffer prior to sequential articulation.

2.4. THE ERROR EQUIVALENCE HYPOTHESIS.

It is being claimed, then, that impending speech is coded in a phonological form and held in a functional Response Buffer prior to its articulation. The same Response Buffer, utilizing the same form of coding, holds items in phonologically-coded sub-span lists in short-term memory (where the degree of exclusive reliance on phonological coding increases as the meaningfulness of the items and their associative, syntactic, or semantic organization decreases). The Error Equivalence Hypothesis states that:

IF ONE PHONEMIC RESPONSE BUFFER MEDIATES BOTH SPONTANEOUS SPEECH PRODUCTION AND PHONOLOGICAL SHORT-TERM MEMORY, AND IF THAT RESPONSE BUFFER IS PRONE TO MAKE CERTAIN PARTICULAR TYPES OF ERROR, THEN THE SAME FORMS OF PHONEMIC ERROR SHOULD BE DETECTABLE IN BOTH SPEECH AND SHORT-TERM MEMORY, AND THEY SHOULD BE INFLUENCED BY THE SAME VARIABLES IN THE SAME WAY.

This hypothesis is at the core of all the experiments reported in this thesis. The guiding strategy was to attempt to categorize satisfactorily the forms of phonemic error occurring in speech and short-term memory, and then to look for possible equivalent pairs. Variables shown to affect one member of the pair in one context peech or short-term memory) were examined for their effects upon the her member of the pair. Where the two members of a pair could be hown to be influenced in similar ways by the same variables, then arsimony was invoked in support of the proposition that the two forms f error in the two different contexts should be seen as reflections of common set of underlying, error-prone processes.

Satisfactory classification of phonemic errors was found to be impler for speech than for short-term memory. Despite the wealth of reported studies of short-term memory errors, considerable divergencies were found as to what constituted distinct forms of error and how known variables influenced those forms. Accordingly, experiments were required (reported in Chapter 3) before a classification could be settled upon. In contrast, although considerable terminological variation is to be found in the studies of phonemic speech errors, it appears that these differences are of names only, and that the same phenomenal forms of error have been recognized (often independently) by many investigators.

2.5. THE CLASSIFICATION OF PHONEMIC SPEECH ERRORS.

Four basic types of phonemic speech error can be recognized, although subdivisions of these types are possible. The four types which will be described here are the Spoonerism, the segmental replacement error, phoneme masking, and the haplology.

2.5.1. The Spoonerism.

The Spoonerism is essentially a positional error which involves the misplacement of consonants or vowels (or combinations such as consonant clusters or non-morphemic syllables). The term 'Spoonerism' has, on occasion, been extended to misorderings of words, but it will be restricted here to purely phonological errors. Three types of Spoonerism can be distinguished (examples taken from Appendix to

Fromkin, 1973a):-

a) Anticipation.

A reading list ⟶ A leading list

A phoneme is anticipated in error, but also correctly spoken at its appropriate place.

b) Perseveration.

Michael Halliday ⟶ Michael Malliday

A phoneme which has been correctly spoken at its appropriate place is repeated as an error.

c) Reversal.

New York ⟶ Yew Nork

With this ring I thee wed ⟶ With this wing I thee red

A combination of anticipatory and perseverative errors, resulting in a mutual exchange (or 'metathesis') between two phonemes.

Although the above examples are of consonant Spoonerisms, anticipations, perseverations and reversals can equally involve consonant clusters, vowels, syllables etc. Thus, an example of a vowel reversal (also from Fromkin, 1973a) is:

bed bugs ⟶ bud begs

It is possible to distinguish further (cf. Section 2.3.) between Spoonerisms occurring within tone-groups, and those occurring between tone-groups. Within tone-group Spoonerisms are many times more frequent than between tone-group Spoonerisms (Boomer and Laver, 1968; Garrett and Shattuck, 1974, as cited in Fodor, Bever and Garrett, 1974, Ch. 7).

2.5.2. Phoneme Masking.

'Phoneme masking' is a term used by Mackay (1969) to describe a form of phonemic error which Sturtevant (1947), following Meringer and

Mayer (1895), described as 'dissimilation' and defined as an error in which "a succession of identical articulations or phonemes or group of phonemes is altered by the total or partial loss of one of them". A recurring phoneme may be lost either at its first occurrence (anticipatory masking), or at its second occurrence (perseveratory masking). Alternatively, the masked phoneme may be changed into a different, but more or less similar, phoneme. Examples given by Sturtevant (1947) include:-

a) Anticipatory masking (with omission).

Gabriel Ugron ⟶ Gabiel Ugron

b) Perseveratory masking (with change).

and the rate raised ⟶ and the rate lai....raised.

2.5.3. Segmental replacement.

Segmental replacement errors, like phoneme masking errors, are relatively uncommon, however their occurrence is sufficiently well documented to warrant their inclusion here as a separate category. This is essentially a default category, in that an error is classified as a segmental replacement if a consonant or vowel is substituted by another phoneme which has not occurred in the nearby context (hence the error is not a Spoonerism), nor was the substituted phoneme one of a sequence of identical phonemes (hence the error is not an instance of phoneme masking). Examples from Fromkin (1973a) include:-

all these magnificent sights ⟶ all these bagnificent sights

phonetic data ⟶ pholetic data

2.5.4. Haplology.

Sturtevant (1947) defines haplology (otherwise known as "ellipsis" or "telescoping") as "the loss of one of two identical phonemes or groups of phonemes and all that should stand between them".

Examples cited include:-

the atlas of Italy ⟶ the atly

Rhine wines of that type ⟶ Rhines of that type

Fromkin (1973a, Appendix) lists examples in which haplology occurs without the occurrence of identical segments bounding the omitted portion, for example:-

shrimp and egg souffle ⟶ shrig souffle

Thus, identical bounding phonemes do not appear to be a necessary condition for the occurrence of haplology, but it may well be a facilitating condition.

It should be noted that the haplology complements the Spoonerism as evidence for phonological preplanning. The "shrig souffle" example above could not have occurred if the word 'egg' had not been available as a potential phonological sequence when the speaker began to utter the word 'shrimp'.

SUMMARY.

1. The Logogen Model developed by Morton represents a viable alternative to the input model as an account of human language and memory performance.

2. The Response Buffer within the Logogen Model holds potential verbal responses in a phonemic (articulatory) form, and serves many of the functions of the Primary Memory component of the input model. The Response Buffer is the locus of phonemic errors within the model.

3. Evidence from co-articulation, vowel harmony, segmental duration effects and, in particular, Spoonerism errors in speech shows that stretches of impending speech are encoded in phonological form before being articulated. The phonological unit of "tone-group" is suggested as a candidate for the unit of preplanning, and the Response Buffer is proposed as a means of storing planned tone-groups.

4. If the same phonemic Response Buffer mediates both speech production and phonemic short-term memory, and if that buffer is prone to certain characteristic forms of error then, it is argued, the same forms of phonemic error, affected by the same variables, should occur in both speech and short-term memory.

5. Four categories of phonemic error in speech occur. These are Spoonerisms, Phoneme Masking, Segmental Replacement, and Haplology.

CHAPTER 3.

PHONEMIC SIMILARITY EFFECTS IN SPEECH AND SHORT-TERM MEMORY.

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3.1. GENERAL INTRODUCTION: THE CLASSIFICATION OF IMMEDIATE RECALL ERRORS.

There is little in the early literature concerned with immediate recall errors (though see Smith, 1895 and Watkins, 1914); the modern study of these errors originates with the work of Conrad (1959). Conrad attempted to classify the errors occurring in immediate written (or dialled) recall of subspan lists of auditorily-presented digits. Four types of error were identified, namely:

1) Omissions - the subject leaves a blank or says 'don't know' (instances where the subject forgets completely and guesses at random were regarded by Conrad as being effectively omissions).

2) Transpositions - a stimulus item is recalled in the response sequence at the wrong serial position.

3) Serial order intrusions - a stimulus item is replaced at recall by the item which occupied the same serial position in the subject's recall of the previous stimulus list. This type of error was shown by Conrad (1960) to occur at greater-than-chance frequency.

4) Substitutions - the error item was not present in the stimulus list, nor did it occur at the same serial position of the immediately-preceding list.

Conrad (1964, 1965) went on to demonstrate that the error matrices for both substitution and transposition errors in immediate recall of visually-presented 6-letter sequences correlated significantly with the distribution of errors found when subjects attempted to identify the same letters presented auditorily, against a background of white noise. On the basis of these correlations , Conrad (1965) proposed that substitutions (recall confusions) and transpositions represent superficially different forms of the same type of error, which he termed the 'acoustic confusion error'. Conrad (1965:109) stated, however, that: "What would be crucial [in distinguishing between transpositions and substitutions] is a variable that, in the defined case, could be shown to affect order of items differentially from the items themselves".

One variable which has since been shown to act differentially upon order errors (transpositions) and item errors (substitutions) is serial position. Transpositions show a U-shaped distribution, with items in the middle of the stimulus list being more prone to transpose than those at the ends of the list (e.g. Conrad, 1959; Ryan, 1969; Bjork and Healy, 1974, Hitch, 1974). In contrast, distribution of substitution errors across serial positions is effectively flat (e.g. Aaronson, 1968; Bjork and Healy, 1974; Healy, 1974; Hitch, 1974). Also, different serial position curves for transpositions and substitutions after intervening activity between presentation and recall have been reported by Donaldson and Glathe (1969) and Fuchs (1969). Estes (1972) has shown that the total frequencies of transpositions and substitutions in recall of 4-letter lists peak after different numbers of shadowed digits interposed between presentation and recall.

In this chapter, the error equivalence hypothesis (Section 2.4.) will be invoked to propose that transpositions and substitutions in short-term memory have as their equivalent error forms in spontaneous speech the phonemic Spoonerism (Section 2.5.1.)

and the segmental replacement error (Section 2.5.3.) respectively. Experiments I - III will be concerned to show that phonemic similarity affects these proposed equivalent pairs in directly comparable ways.

3.2. INTRODUCTION TO EXPERIMENTS I AND II.

3.2.1. Spoonerisms and transpositions.

Phonemic Spoonerisms (Section 2.5.1.) involve the misarrangement of phonemes from their correct (intended) order. Spoonerisms may be anticipatory (example 1 below), perseverative (example 2) or reversals (example 3), and may involve vowels as well as consonants (example 4).

Example 1: a reading list ⟶ a leading list.

Example 2: Michael Halliday ⟶ Michael Malliday.

Example 3: heap of rubbish ⟶ reap of hubbish.

Example 4: feed the pooch ⟶ food the peach.

(Examples taken from Appendix to Fromkin, 1973a).

Transpositions in short-term memory are, similarly, errors involving the misarrangement of items from their correct order; in this case items in stimulus lists of disconnected letters, digits, syllables, words etc., presented to subjects for immediate, ordered recall. The structural similarity between Spoonerisms and transpositions has been noted by Baars and Motley (1974) who ascribed these errors to an 'output short-term memory' (see Section 2.2.2.). Also, Baddeley and Hitch (1974) incorporated into their 'Working Memory' system a 'phonemic response buffer' which apparently shares all or many of the characteristics of Morton's Response Buffer (Sections 2.1.2. to 2.1.4), and which may play a role in determining the occurrence of both acoustic similarity effects in memory and perhaps also of such speech errors as tongue twisters and Spoonerisms' (Baddeley and Hitch, 1974). The more specific claim being investigated here is that the only important difference between phonemic Spoonerisms and transpositions is the origin of the material involved - in the former case it is the end-product of semantic, syntactic and lexical planning whereas in the latter case it is the experimentally-presented stimulus list. In both situations the material is held in the phonemic Response Buffer where systematic errors may arise during storage or at retrieval.

A survey of the literature on Spoonerisms and transpositions reveals a number of points of similarity:

i) Spoonerisms and transpositions are, of course, both errors of serial ordering, and both constitute the largest single class of error in their respective domains (Spoonerisms: Cohen, 1966; Fromkin, 1971; Transpositions: Conrad, 1959; Hitch, 1974). Fromkin (Introduction to 1973a:42) notes that the great majority of Spoonerisms involve single pairs of phonemes, and that multiple Spoonerisms (e.g. example 5) are rare.

Example 5. <u>thr</u>ee <u>t</u>oed <u>sl</u>oth ⟶ <u>sl</u>ee <u>thr</u>oed <u>t</u>oth

Similarly, Conrad (1965) observed that 83 per cent of transposition errors occurring in the immediate recall of 6-letter sequences were paired errors; multiple transpositions of 3 items being rare, and transpositions of 4 or more items rarer still.

ii) Both consonants and vowels may exchange in Spoonerisms but, to quote Garrett (1975:141) 'identity as consonant or vowel seems crucial; consonants exchange with other consonants but not with vowels, and conversely. There are virtually no plausible exceptions to this generalization in the MIT corpus [of 3,400 errors] and none that I am aware of in published reports of other error corpora'. This noninteraction between consonants and vowels is also true of short-term memory. A subject could, in repeating a syllable sequence like ke mi lu pa so produce a response sequence such as ke mi pl ua so, where pl is a consonant sequence in which [l] is syllabic (cf 'people') and ua is a vowel sequence (cf 'Sue asks'). Such errors never seem to occur, and the effect is so pervasive that no-one has previously felt obliged to comment upon it.

iii) Ryan (1969), Healy (1974), Hitch, (1974), and Shiffrin and Cook (1978) have observed that the probability of two items transposing in short-term memory declines sharply as the distance between the items concerned increases. Likewise, Cohen (1966), Nooteboom (1967, 1969), and MacKay (1970) have observed a marked tendency for Spoonerisms to involve phonemes in adjacent syllables (within-syllable reversals are rare), with the probability of exchange between two phonemes declining rapidly as the number of intervening syllables increases, up to a maximum separation of 8 or 9 syllables (in accordance with the maximum length of tone-groups - cf. Sections 2.3. and 2.5.1.).

3.2.2. Phonemic similarity and order errors.

Nooteboom (1967) examined a corpus of 545 consonant Spoonerisms in Dutch and discovered that in 25 percent of errors, the vowels of the two syllables concerned were identical (if vowel identity played no part in determining consonant Spoonerisms, by Nooteboom's estimate, then one would expect, by chance alone, that the origin and target syllables would share identical vowels in only about 10 per cent of errors). The same effect must be at work in determining MacKay's (1970) observation that in 78 per cent of phonemic Spoonerisms the origin and target phonemes are followed by identical repeated phonemes. This effect of accompanying vowel identity on consonant Spoonerisms might be termed the contextual similarity effect.

A second effect of phonemic similarity on Spoonerisms concerns the intrinsic similarity of the two phonemes involved. Nooteboom (1967) analyzed 143 Dutch Spoonerisms involving a set of 11 consonant phonemes which could be distinguished one from another by means of 3 distinctive feature oppositions (voiced/voiceless, fricative/stop, and labial/dental/velar). 70 per cent of Spoonerisms differed on only one distinctive feature, 25 per cent differed on two distinctive features, and only 5 per cent differed on all 3 distinctive features (the chance levels were 36%, 46% and 18% respectively). Comparable results have been reported by MacKay (1970) and van den Broeke and Goldstein (1977), confirming what might be termed the feature similarity effect, whereby phonemes which are similar in terms of their distinctive feature descriptions (i.e. phonetically similar) are more likely to exchange than are dissimilar phonemes.

In the field of short-term memory, a large number of experiments have looked at the effects of phonemic similarity on error distribution. Unfortunately, from the present viewpoint, these studies have either failed to distinguish between varieties of error or they have failed to separate out the two aspects of similarity (contextual similarity and feature similarity), or both. Experiment I, therefore, was designed to test for the separate effects of contextual similarity and feature similarity on transposition errors in short-term memory.

EXPERIMENT I.

3.3. INTRODUCTION.

Experiment I had 2 conditions. The first condition (ALL-DIFFERENT VOWEL CONDITION) involved the immediate recall of lists of 5 consonant-vowel (CV) syllables. The consonants and vowels were both drawn from sets of 5, with each consonant and vowel occurring only once per list. Thus all errors involving the stimulus set were, by definition, transpositions of consonants, vowels, or syllables. This allowed a test of the feature similarity effect on consonant transpositions which was expressed as Hypothesis 1:-

Hypothesis 1. The frequency of transposition between pairs of consonants will be proportion al to the number of distinctive feature values shared in common (i.e. inversely proportional to the number of contrastive features).

The second condition (ALL-SAME VOWEL CONDITION) differed from ALL-DIFFERENT VOWEL CONDITION in that all the syllables in any given list shared the same vowel in common. A 'contextual similarity effect' should manifest itself as a higher frequency of consonant transpositions in this condition as compared with the ALL-DIFFERENT VOWEL CONDITION. This prediction was expressed as Hypothesis 2.

Hypothesis 2. Consonant transpositions will be significantly more frequent in the ALL-SAME VOWEL CONDITION than in the ALL-DIFFERENT VOWEL CONDITION.

The design of the ALL-DIFFERENT VOWEL CONDITION allowed the testing of further predictions drawn from studies of naturally-occurring Spoonerisms. Cohen (1966), Nooteboom (1967, 1969) and MacKay (1970) have shown that consonant Spoonerisms are more common than vowel

Spoonerisms which are, in turn, more frequent than Spoonerisms of entire syllables. These observations led to the predictions embodied in Hypothesis 3.

<u>Hypothesis 3.</u> In the ALL-DIFFERENT VOWEL CONDITION, transpositions of consonants will be significantly more frequent than transpositions of vowels which will, in turn, be significantly more frequent than whole-syllable transpositions.

<u>3.4. METHOD.</u>

<u>3.4.1. Design.</u>

The ALL-DIFFERENT VOWEL CONDITION consisted of 20 lists of 5 consonant-vowel (CV) syllables. 5 consonants were used (/b/, /m/, /n/, /p/ and /s/) with each consonant occurring only once per list, and 4 times at each of the serial positions 1 to 5 in the 20 stimulus lists of this condition. There were 10 possible pairs of consonants (bm, np, ms etc.), each of which occurred twice at each of the pairs of serial positions 2 & 3, 3 & 4, 1 & 3, 2 & 4 and 3 & 5. (Each consonant pair occurred 1 to 3 times at each of the remaining 5 pairs of serial positions).

5 vowels were used (/ɪ/ as in <u>pit</u>, /e/ as in <u>pet</u>, /æ/ as in <u>pat</u>, /ɒ/ as in <u>pot</u>, and /uː/ as in <u>pool</u> - henceforth i, e, a, o and u respectively). Each vowel occurred only once per list, and 4 times at each of the serial positions 1 to 5 in the 20 lists. Each of the 20 possible CV syllables was used 3 to 5 times in all, and occurred not more than twice at any one serial position. Thus, a typical list of the ALL-DIFFERENT VOWEL CONDITION might be:

	bi	me	na	po	su
<u>or</u>	se	ba	pi	nu	mo

The consonant structure of the lists of the ALL-SAME VOWEL CONDITION was exactly the same as that of the ALL-DIFFERENT VOWEL CONDITION. The difference between the 2 conditions lay in the distribution of vowels. In the ALL-SAME VOWEL CONDITION, all the syllables in any one list contained the same vowel, for example:

mo po so bo no

or ne be me se pe

There were 4 /o/ lists, 4 /e/ lists, and so forth. These were randomly interleaved in the presentation order.

3.4.2. Subjects.

12 subjects were tested. All were students at the Department of Psychology, University of Edinburgh, and all were paid £1 for their co-operation.

3.4.3. Apparatus.

Stimuli were recorded on tape using a Pye Cambridge tape recorder, with a 3M cardiod microphone, and were presented to the subject through Eagle International headphones.

3.4.4. Procedure.

Subjects were tested individually. The stimuli were presented auditorily through headphones. The syllables of each list were presented at a rate of one per second, and the 5th syllable was followed at the same rate by a recall tone (7 kc/sec., lasting 0.5 sec.). The subject spoke each syllable aloud as it was presented and then attempted to speak all 5 syllables in their correct order after the recall tone. Subjects were instructed to guess a syllable if possible when they were unsure, otherwise to say 'blank' at the appropriate point in the sequence. 12 seconds were allowed for recall, after which a warning tone (also 7 kc/sec. for 0.5 sec.) was presented, indicating that the next list would begin in 2 seconds.

Both conditions were preceded by auditorily-presented instructions which included 3 example lists. 6 Practice Lists were given before the 20 stimulus lists of each condition. Half the subjects received the instructions, Practice Lists and stimulus lists of the ALL-DIFFERENT VOWEL CONDITION, then a 5 minute rest period, followed by the instructions and lists of the ALL-SAME VOWEL CONDITION. The remaining subjects received the 2 conditions in the reverse order.

The subjects' spoken responses were recorded during the experimental session, and were also noted by E., seated behind and to the left of the subject. E's transcription was later checked against the recording of the session.

At the completion of both conditions, subjects were asked to state which, if either, of the two conditions they had found easier, and to describe any mnemonic strategies adopted during the experiment.

3.5. RESULTS.

Having each subject repeat each syllable on presentation allowed for a check on possible misperceptions. In fact, there were no purely perceptual errors on any of the stimulus lists. Only response sequences containing 5 items (including 'blank') were scored (only 4 sequences had to be rejected for failure to meet this criterion - 3 in the ALL-SAME VOWEL CONDITION and 1 in the ALL-DIFFERENT VOWEL CONDITION). On no occasion did an error involve the substitution of either a consonant or a vowel which was not one of the stimulus set.

3.5.1. All-different vowel condition.

Any consonant, vowel or syllable recalled at an incorrect serial position in the response sequence was scored as a transposition. Syllable transpositions were not also scored as consonant and vowel transpositions.

373 transposition errors were scored, at an average of 1.56 errors per list. There were 279 consonant transpositions (74.8%), 69 vowel transpositions (18.5%) and 25 syllable transpositions (6.7%). Frequencies of consonant, vowel and syllable transpositions were compared using the Wilcoxon matched-pairs signed-ranks test (Siegel, 1956). Consonant transpositions occurred significantly more often than both vowel transpositions ($N = 12$, $T = 0$, p .005, 1-tailed) and syllable transpositions ($N = 12$, $T = 0$, p .005, 1-tailed), and vowel transpositions occurred significantly more often than syllable transpositions ($N = 10$, $T = 6.5$, p .025, 1-tailed). Hypothesis 3 was thus supported.

A subsample of the consonant transpositions was employed to test Hypothesis 1 concerning the effects of feature similarity. The subsample in question was the 165 consonant transpositions which occurred between serial positions 2 and 3, 3 and 4, 1 and 3, 2 and 4, and 3 and 5. In all cases the error consonant replaced the original target consonant of the stimulus syllable leaving the vowel of the target syllable unaltered and correct. Table 3.1 shows the matrix of the transpositions obtained.

Wickelgren's (1966) distinctive feature system was used to test Hypothesis 1. The system describes consonants uniquely in terms of 2 binary features (Voicing (voiced/unvoiced) and Nasality (nasal/non-nasal)), a 3-valued feature Openness (narrow, medium and wide),

TARGET CONSONANT

ERROR CONSONANT		b	m	n	p	s
	b	-	18	8	10	4
	m	22	-	13	7	6
	n	7	17	-	3	6
	p	11	3	2	-	6
	s	3	6	4	9	-

Table 3.1. Matrix of consonant transpositions between serial positions 2&3, 3&4, 2&4, and 3&5 in ALL-DIFFERENT VOWEL CONDITION.

	DISTINCTIVE FEATURE			
	Voicing	Nasality	Openness	Place
b	1	0	0	0
m	1	1	0	0
n	1	1	0	1
p	0	0	0	0
s	0	0	1	2

Table 3.1. Distinctive feature description of the 5 stimulus consonants used in Experiment I.

and a 5-valued Place of Articulation feature (from 0 = bilabial to 5 = velar or unrestricted). Table 3.2 shows the description of the five stimulus consonants in terms of these features.

A particular pair of consonants may differ on 4 features (/s/vs/m/ and /s/vs/n/), 3 features (/b/vs/s/ and /n/vs/p/), 2 features (/b/vs/n/, /m/vs/p/ and /p/vs/s/), or only 1 feature (/b/vs/m/, /b/vs/p/ and /m/vs/n/). Hypothesis 1 predicts that the frequency of transposition between a given pair of consonants will be greater than the frequency of transposition between any other pair of consonants which have fewer distinctive feature values in common (i.e. more contrastive features). Table 3.2 yields 26 such binary predictions. For example, /b/ and /n/ differ on 2 distinctive features and should, therefore, transpose more frequently than /s/ and /m/, /s/ and /n/, /b/ and /s/, and /b/ and /p/ which differ on 3 or 4 features, but less frequently than /b/ and /m/, /b/ and /p/, and /m/ and /n/ which differ on only one feature.

The individual cells of Table 3.1 were summed across the diagonal of the matrix (that is, the frequencies with which, say, /b/ replaced /m/ and /m/ replaced /b/ were summed) and the binary predictions drawn from Table 3.2 were tested against the sums obtained. 22 of the 26 binary predictions were confirmed by the data (an 85 per cent correct level of prediction). With a chance level of 50 percent, this represents a highly significant corroboration of Hypothesis 1 ($\chi^2 = 12.46$, df = 1, $p < .001$).

3.5.2. All-same vowel condition.

There is only one form of transposition error in the ALL-SAME VOWEL CONDITION. It is a matter for debate whether such errors should be regarded as equivalent to consonant transpositions alone in the ALL-DIFFERENT VOWEL CONDITION, or to transpositions of both consonants and syllables in that condition. Fortunately, the decision between these two alternatives makes no difference to the interpretation of the results. 317 transposition errors were scored in the ALL-SAME VOWEL CONDITION. This was not significantly more frequent than either the 279 consonant transpositions of the ALL-DIFFERENT VOWEL CONDITION ($N = 12$, $T = 22.5$, n.s.) or the 304 combined consonant and syllable transpositions of that condition ($N = 12$, $T = 27.5$, n.s.). Hypothesis 2 concerning the predicted contextual similarity effect on consonant transpositions was, therefore, not supported by the data.

205 transpositions in the ALL-SAME VOWEL CONDITION occurred between serial positions 2 and 3, 3 and 4, 1 and 3, 2 and 4, and 3 and 5. These were combined into a matrix (Table 3.3) and tested for the effects of feature similarity in exactly the same way as that described for consonant transpositions in the ALL-DIFFERENT VOWEL CONDITION. 18 of the 26 binary predictions were supported by the data (69% correct prediction). This is less than the 85% level for the ALL-DIFFERENT VOWEL CONDITION, but is still significantly better than chance ($\chi^2 = 3.45$, $df = 1$, $p < .05$).

3.6. DISCUSSION.

Hypotheses 1 and 3 were both strongly supported by the data, i.e.:

1. The frequency of transposition between pairs of consonants was shown to be affected by their intrinsic phonetic similarity, as defined in terms of the number of shared distinctive feature values, such that phonetically similar consonants are more prone to transpose than dissimilar consonants (the feature similarity effect).
2. Consonant transpositions were shown to occur more frequently than vowel transpositions which, in turn, occur more frequently than syllable transpositions.

TARGET CONSONANT

ERROR CONSONANT	b	m	n	p	s
b	-	12	16	13	7
m	13	-	19	5	10
n	16	14	-	8	6
p	12	10	4	-	7
s	6	10	8	9	-

Table 3.3. Matrix of transpositions between serial positions 2 & 3, 3 & 4, 1 & 3, 2 & 4, and 3 & 5 in the ALL-SAME VOWEL CONDITION.

Hypothesis 2, in contrast, was not upheld: consonant transpositions between syllables sharing a common vowel were not significantly more frequent than transpositions between syllables having different vowels. There was no evidence, therefore, for the presence of a contextual similarity effect. However, 8 out of the 12 subjects did make more transposition errors in the ALL-SAME VOWEL CONDITION than in the ALL-DIFFERENT VOWEL CONDITION and, furthermore, these individual differences in subject performance appeared to be related to differences in recall strategies adopted by the subjects. Specifically, 7 subjects (including 6 of the 8 who made more transpositions in the ALL-SAME VOWEL CONDITION than in the ALL-DIFFERENT VOWEL CONDITION) claimed to operate on the 'sound' of the syllables alone, without trying to detect meaningful or associable sequences. The remaining 5 subjects (including 3 of the 4 whose performance ran counter to the prediction of Hypothesis 2)adopted a variety of associative mnemonic strategies, and were unanimous in agreeing that some strategies were more effective in the ALL-SAME VOWEL CONDITION than in the ALL-DIFFERENCE VOWEL CONDITION.

In the light of these observations, it was felt to be worthwhile to attempt another experiment in search of a contextual similarity effect - in this case using a design which did not permit differences in associability to differentiate between conditions as they may have done in Experiment I.

EXPERIMENT II.

3.7. INTRODUCTION.

In the previous experiment, the stimulus lists comprised either 5 syllables containing the same vowel or 5 containing different vowels, and the two sorts of list were presented separately. In the present experiment, in contrast, the two sorts of list used differed only in one <u>critical pair</u> of syllables, and only transpositions between the critical pair in a list were considered. Briefly, in the ALL-DIFFERENT VOWEL CONDITION of Experiment II, the vowels contained within the critical pair of syllables in a list were different from each other and different also from the vowels of the other 3 syllables in the list. In the REPEATED VOWEL CONDITION, the syllables of the critical pair contained the same vowel (the three non-critical syllables being identical to their counterparts in the ALL-DIFFERENT VOWEL CONDITION). The critical pair of syllables, between which consonant transpositions were scored, were positioned at serial positions 2 and 3, 3 and 4, or 2 and 4. To minimize further the differential use of mnemonic strategies, the lists of the two conditions were randomly interleaved in the presentation order.

Several subjects in Experiment I reported finding the need to repeat each syllable aloud on presentation distracting. In view of the absence of perceptual errors in Experiment I, that requirement was removed from Experiment II. The presentation rate was increased slightly from 1 syllable per second to 3 syllables every 2 seconds.

3.8. METHOD.

3.8.1. Design.

Two conditions were employed - an ALL-DIFFERENT VOWEL CONDITION and a REPEATED VOWEL CONDITION.

The lists of the ALL-DIFFERENT VOWEL CONDITION were devized first. There were 30 lists in this condition, each consisting of 5 consonant-vowel (CV) syllables. 5 consonants were used (/b/, /m/, /n/, /p/, and /s/) and 5 vowels (/æ/, /e/, /ɪ/, /ɒ/, and /uː/ - henceforth a, e, i, o and u espectively). Each consonant and each vowel occurred only once per ist in the ALL-DIFFERENT VOWEL CONDITION, and 6 times at each of the erial positions 1 to 5 in the 30 stimulus lists. Each of the 25 ossible CV syllables was used 5 to 8 times, though not more than twice t any particular serial position. The lists were devized in such a way hat each of the 10 possible consonant pairs occurred 3 times at each of he pairs of serial positions 2 and 3, 3 and 4, and 2 and 4.

One pair of syllables in each list was designated as a critical air, 10 critical pairs being at serial positions 2 and 3, 10 at serial ositions 3 and 4, and 10 at serial positions 2 and 4. Each of the 0 different pairs of consonants occurred once in a critical pair at erial positions 2 and 3, once at serial positions 3 and 4, and once at erial positions 2 and 4.

The lists of the REPEATED VOWEL CONDITION were derived from hose of the ALL-DIFFERENT VOWEL CONDITION. This was done by replacing he vowel of one of the critical pair in each list by the vowel of the ther member of the pair. The following example shows a list of the LL-DIFFERENT VOWEL CONDITION with the critical pair of syllables at erial positions 2 and 3 (underlined). The derived list of the EPEATED VOWEL CONDITION is shown underneath the parent list, being dentical to the parent list apart from the duplicated vowel in the yllables of the critical pair.

ALL-DIFFERENT VOWEL CONDITION	sa	bi	pe	no	mu
REPEATED VOWEL CONDITION	sa	bi	pi	no	mu

Each of the 10 pairs of consonants occurred once in a ritical pair at each of the pairs of serial positions involved, with different accompanying repeated vowel on each occurrence. Each of he 5 vowels was used to form a repeated vowel critical pair from 1 to 3 times at each of the pairs of serial positions 2 and 3, 3 and 4, and 2 and 4, and 5 to 7 times in all.

In summary, each list of 5 syllables in the ALL-DIFFERENT VOWEL CONDITION had its derived counterpart in the REPEATED VOWEL CONDITION. The consonant structure of the two versions of each list was the same. The syllables in the noncritical positions were the same, providing identical contexts within which transpositions between critical pairs of syllables (containing different vowels in the ALL-DIFFERENT VOWEL CONDITION and identical vowels in the REPEATED VOWEL CONDITION) could occur.

The stimulus lists of the 2 conditions were intermingled for presentation. This was done by segregating the lists into 2 sets of 30 lists each (Set A and Set B), such that the ALL-DIFFERENT VOWEL and REPEATED VOWEL versions of any list occurred in different sets. (To further balance the sets, if the REPEATED VOWEL list containing a particular consonant pair in the critical items of serial positions 2 and 3 was placed in Set A, then a REPEATED VOWEL list with the same consonants in critical items at serial positions 3 and 4 was placed in Set B, and vice-versa. Lists of the REPEATED VOWEL CONDITION with the critical pairs at serial positions 2 and 4 were divided equally between Sets A and B).

Within each Set, ALL-DIFFERENT VOWEL AND REPEATED VOWEL lists were randomly interleaved in the presentation order.

3.8.2. Subjects.

22 subjects took part in the experiment. All were students of the University of Edinburgh, Department of Psychology, and all were paid £1.

5.8.3. Apparatus and materials.

Stimuli and responses were recorded on tape using a PYE CAMBRIDGE tape recorder and a 3M cardiod microphone. Stimuli were presented to the subject through EAGLE INTERNATIONAL headphones.

5.8.4. Procedure.

Instructions and stimuli were recorded on tape and presented auditorily to the subject through headphones. Subjects were tested individually. At the start of the experiment the following instructions were given:-

'In this experiment you will be asked to listen to, and then repeat, lists of 5 syllables. The syllables are made up from the consonants b, m, n, p and s [pronounced buh, muh, nuh, puh and suh] together with the vowels a, e, i, o and u. In any list the consonants will be all different, but a vowel may occur more than once, for example:

nu sa po ba me

or .... na mo se bi pu.

Each list will be preceded by a warning tone like this ... [example given] which indicates that a new list is about to begin. A second tone will follow the fifth syllable - this is the recall tone, and is your cue to repeat the list of syllables you have just heard in their correct order. Here are a further 3 examples [complete with warning and recall tones].

pi nu su mo ba

si pe bu ma no

bo sa me ne pu

Your task is to listen to the syllables and then speak all five in their correct order after you hear the recall tone. If you are unsure of a particular syllable please guess if possible, otherwise ay 'blank' at the appropriate position in the sequence. You will have 5 seconds to repeat each list. A warning tone will indicate when the ext list is about to begin'.

The stimulus syllables were presented at a rate of 3 every 2 seconds (0.67 secs. per item). The warning tone (7 kc/sec. lasting 0.5 ecs.) preceded the first syllable of each list by 2 seconds, and a imilar recall tone followed 0.67 seconds after the fifth syllable. 5 seconds were allowed for spoken, ordered recall.

5 Practice lists were presented after the instructions 2 ALL-DIFFERENT VOWEL lists and 3 REPEATED VOWEL lists with critical airs at serial positions 2 and 3, 3 and 4, and 2 and 4). Half the ubjects then received the 30 lists of Set A (lasting approximately 0 minutes), then a 5 minute rest period followed by the lists of Set B lasting a further 10 minutes). The remaining subjects received the sets of lists in the reverse order.

The subjects' spoken responses were noted by E., who sat behind and o the left of the subject during the experiment. The responses were lso recorded on tape using a microphone placed on a desk in front of the ubject. E.'s transcription was subsequently checked against the ecording of the session.

.9. RESULTS.

All the response sequences contained 5 items (counting 'blank' s an item) so all were scored for transpositions and reversals, where a eversal error involves 2 mutual transpositions between critical items. n the REPEATED VOWEL CONDITION, transpositions between critical pairs ere only scored if the vowel of the target (error) syllable was correctly ecalled. Likewise, in the ALL-DIFFERENT VOWEL CONDITION consonant ransnositions between critical pairs of syllables were scored only if he vowel of the target syllable was correctly recalled. Transpositions nd reversals of whole syllables between critical pairs of items in the LL-DIFFERENT VOWEL CONDITION were also scored. (see paragraph on p. 77a).

136 transpositions between critical pairs occurred in the EPEATED VOWEL CONDITION. In the ALL-DIFFERENT VOWEL CONDITION, 9 consonant transpositions and 17 syllable transpositions between critical airs were scored. As mentioned previously, it is arguable whether one hould compare transpositions involving syllables sharing the same vowel critical pairs in the REPEATED VOWEL CONDITION) with only consonant ransponsitions between syllables having different vowels, or with the ombined frequencies of consonant and syllable transpositions between such tems (critical pairs in the ALL-DIFFERENT VOWEL CONDITION). ransponsitions between critical pairs in the REPEATED VOWEL CONDITION ere significantly more frequent than consonant transpositions between ritical pairs in the ALL-DIFFERENT VOWEL CONDITION ($N = 20$, $T = 47.5$, $< .025$, one-tailed), but were not significantly more frequent than the ombined frequencies consonant and syllable transpositions between ritical pairs in that condition ($N = 18$, $T = 53.5$, n.s.).

However, some of the transpositions scored between critical pairs ı both conditions were parts of multiple exchanges involving non-critical ; well as critical items. An effect of contextual vowel similarity .ght be expected to be manifested more clearly in mutual transpositions eversals) between critical pairs. There were 50 such reversals in the :PEATED VOWEL CONDITION, whilst in the ALL-DIFFERENT VOWEL CONDITION ! consonant reversals and 1 syllable reversal between critical pairs re scored. Reversals between critical pairs in the REPEATED VOWEL NDITION were significantly more frequent than consonant reversals

In the ALL-DIFFERENT CONDITION there were 513 lists in which the owels of the two syllables in critical serial positions were correctly ecalled. That is, there were 513 lists (an average of 23.3 per subject) hich were eligible to be scored for the presence or absence of ranspositions or reverals of consonants between critical pairs of serial ositions. In the REPEATED VOWEL CONDITION the number of lists atisfying the eligibility criteria was 493 (an average of 32.4 per ubject). The difference between conditions was not significant (n = 20, = 76.5, n.s.), though the greater number of eligible lists in the ALL-IFFERENT VOWEL CONDITION militated, if anything, against the prediction f more transpositions or reverals between critical pairs of serial ositions in the REPEATED VOWEL CONDITION.

etween critical pairs in the ALL-DIFFERENT VOWEL CONDITION ($N = 20$, $= 45$, $p < .025$, one-tailed) and were also significantly more frequent han the combined frequencies of consonant and syllable reversals between ritical pairs in the ALL-DIFFERENT VOWEL condition ($N = 21$, $T = 56$, $< .025$, one-tailed). These results support the contextual vowel imilarity hypothesis.

As a control to show that the difference in performance between he conditions was restricted to the critical pairs of serial positions, he numbers of non-critical items correctly recalled in each condition ere scored. 1570 non-critical items were correctly recalled in the EPEATED VOWEL CONDITION and 1545 in the ALL-DIFFERENT VOWEL CONDITION. his difference was not significant ($N = 21$, $T = 93.5$, n.s.).

.10. DISCUSSION.

In Experiment II, and unlike Experiment I, the associative ifferences between the two conditions were minimal. There were ignificantly more transpositions between critical pairs in the EPEATED VOWEL CONDITION than consonant transpositions between critical airs in the ALL-DIFFERENT VOWEL CONDITION. There were also significantly ore reversals between critical pairs in the REPEATED VOWEL CONDITION han reversals of either consonants alone, or consonants plus syllables, etween critical pairs in the ALL-DIFFERENT VOWEL CONDITION. These esults confirm the presence in short-term memory of a contextual vowel imilarity effect comparable to that already known to influence pooonerisms in spontaneous speech and, as such, support the error quivalence hypothesis (Section 2.4.).

The results of Experiment II appear to contradict the results f Marcer, Matthews and Dring (1977) who failed to find significant ifferences between the numbers of lists of acoustically similar or coustically different letters or words recalled in the correct order fter retention intervals varying from 0 to 16 seconds. One may note, owever, that of the 9 comparisons of similar versus dissimilar letters r words reported in their Table 1, 2 showed no difference in mean ercentage recall whilst the remaining 7 all showed better recall of coustically different sequences than the acoustically similar sequences. arcer et al's results also contradict the findings of Wickelgren (1965a) ho found poorer recall of acoustically-similar letters, attributable to oorer recall of the positions of similar items. The interaction etween similarity and order errors, is also reported by Thomassen (1970, xperiment 1) and discussed by Broadbent (1970; 1971: 382-3).

.11. INTRODUCTION TO EXPERIMENT III.

Experiments I and II demonstrated equivalent effects of phonemic imilarity on transpositions in short-term memory and Spoonerisms in pontaneous speech. Experiment III focusses attention on another utatively equivalent pair, namely the substitution error in short-term emory (Section 3.1.) and the segmental replacement error in speech Section 2.5.3.).

Segmental replacement errors (e.g. examples 6 and 7 below - rom Appendix to Fromkin, 1973a) are apparently much less common than poonerisms in normal speech (although they may also be considerably less asily detected than Spoonerisms since it is known that single, inimally-distorted mispronunciations tend to pass unnoticed in the erception of ongoing speech (Cole, 1973; Marslen-Wilson and Welsh, 1978)).

6) a transformational rule ⟶ a transpormational rule.

7) other committees of that sort ⟶ ... of that hort - sort.

Because of the small numbers of segmental replacements ecorded in the literature, quantitive studies of phonemic similarity ffects have not been carried out. However, since virtually all such rrors that have been reported involve changes of only a single istinctive feature between the intended phoneme and the error - this hen perceptual biases would tend to militate against the registration f such errors - it seems safe to assume a strong influence of feature imilarity upon the generation of segmental replacements.

Conrad (1964) examined substitution errors in immediate ecall of visually-presented lists of 6 letters. A matrix of substitutions as obtained for those instances where the response sequence contained nly one error. This matrix of recall confusions was compared with he matrix of perceptual confusions obtained when subjects identified etters presented auditorily against a background of white noise. Spearman's coefficient (r_s) of + 0.64 between the two matrices was aken to establish 'beyond any reasonable doubt that even with visual resentation of material to be memorised, when recall errors occurred they ere similar in nature to hearing errors'. (Conrad, 1964: 78). nfortunately, Conrad's sample of substitution errors included serial rder intrusions and also repetitions of letters correctly recalled at heir appropriate serial positions. (Conrad, 1976, personal communication). rguably these latter errors would be better classed as anticipatory or erseverative transpositions. Experiment III was designed, therefore, test the effect of phonemic similarity on substitution errors in hort-term memory, using a "purer" sample of substitutions among onsonant phonemes (rather than letters), and using distinctive features provide a similarity metric, rather than correlating with perceptual onfusion errors.

.12. METHOD.

.12.1. Design.

The stimuli for this experiment were lists of 5 consonant-owel syllables (or ' digrams') in which the vowel letter was always 'A', hile the initial consonant of each syllable was drawn from a set of 16 onsonant letters (B, D, F, G, K, L, M, N, P, R, S, T, V, W, and Z). wo sets of stimulus lists were prepared, each set consisting of 32 yllable sequences. Syllables were semi-randomly assigned to positions n the stimulus lists with the following constraints being applied:-

a) No syllable occurred more than once in each list.

b) No syllable occurred in two successive lists.

c) Each of the 16 possible syllables occurred once at each of the serial positions 1 to 5 in the first 16 stimulus lists, and once again at each serial position in the second 16 lists. Thus, each syllable occurred twice at each serial position in the first set of 32 stimulus lists (Set 1), and twice at each serial position in the second set of stimulus lists (Set 2), making 4 occurrences at each serial position for each syllable in the total of 64 stimulus lists comprising Set 1 and Set 2.

A sequence of 3 typical stimulus lists might be:-

1.	ZA	KA	PA	YA	LA
2.	MA	FA	VA	BA	NA
3.	DA	RA	TA	GA	SA

5 Practice lists were also prepared, again in accordance ith constraints (a) and (b) above.

.12.2. Subjects.

20 subjects (10 male and 10 female) participated in the xperiment. All were students of the University of Edinburgh, epartment of Psychology. All were unpaid volunteers.

5.12.3. Procedure.

Subjects were tested individually. At the start of each experimental session each subject was given the following written instructions:-

> This experiment is concerned with the ability to repeat a list of syllables after reading them. There are 5 syllables in each list, and each syllable is made up of a consonant letter followed by 'A'. A typical list might be VA, PA, DA, LA, ZA. The syllables in each list will appear one at a time at the window of the memory drum in front of you, and the fifth syllable will be followed by '0'. The task is to read each syllable clearly aloud as it appears, and then to repeat all 5, in the order in which they occurred, when the '0' appears. After 8 seconds the small light on top of the memory drum will flash on and off to indicate that the next list is about to begin. 5 practice lists will be given at the start.

The syllables were typed in capital (upper-case) letters and presented to the subjects by means of a memory drum. The syllables in each list were presented at a rate of one per second, and the recall cue ('0') followed the fifty syllable at the same rate. The subject read each syllable aloud as it appeared. Subjects were instructed during the Practice lists to pronounce the vowel letter 'A' in each syllable as the phoneme /ɑ/ (as in 'far', 'half'). Recall following the cue was spoken and ordered, with the subject obliged to speak 5 syllables in response to each stimulus list. 10 seconds were allowed for recall. After 8 seconds a small white light fixed on top of the memory drum was flashed on and off to indicate that the next list would begin shortly. The memory drum was controlled from a distance by E., seated behind and to the left of the subject.

All the subjects received the 5 Practice lists after they had read the instructions. Half the subjects then received the 32 stimulus lists of Set 1, lasting approximately 8 minutes. A 5 minute rest period was then allowed before the 32 lists of Set 2 were presented. The other half of the subjects received Set 2 first, followed by 5 minutes rest, then Set 1. The entire experimental session lasted approximately 30 minutes for each subject.

Subjects' spoken responses were noted by E. during the experiment, and were also recorded by means of a Pye Cambridge tape recorder fitted with a 3M cardioid microphone. E.'s transcription was subsequently checked against the recording.

3.13. RESULTS.

Error analysis was restricted to only those response sequences containing 5 spoken syllables. From a total of 1280 response sequences, 1206 lists (94.2%) satisfied this criterion.

Substitution errors were formally defined as errors in which the correct syllable was replaced at recall by an error syllable, which was not present in the stimulus list (i.e. not a transposition), and did not occur at the same serial position of the preceding stimulus or response sequence (i.e. not a serial order intrusion error). A total of 1783 syllables were incorrectly recalled, of which 360 (i.e. 20.2%) satisfied the above criteria and were classified as substitutions.

The procedure for analyzing phonemic similarity effects was that used by Wickelgren (1966) and Sales, Haber and Cole (1968). The 360 substitutions were collected into a matrix (Table 3.4.) with

STIMULUS SYLLABLES

SUBSTITUTING SYLLABLE

[illegible]	DA	FA	GA	KA	LA	MA	NA	PA	RA	SA	TA	VA	WA	YA	ZA
[illegible]	TA	YA	NA	GA	NA	NA	WA	TA	YA	VA	GA	YA	YA	NA	NA
[illegible]	11	6	3	7	7	8	4	7	6	2	3	7	9	5	4
[illegible]	YA	KA	BA	FA	TA	YA	GA	MA	NA	YA	FA	WA	NA	RA	YA
[illegible]	6	5	2	2	4	4	3	6	5	2	2	6	5	3	3
[illegible]	GA	NA	DA	NA	YA	BA	MA	FA	WA	DA	LA	GA	LA	TA	FA
[illegible]	5	3	2	2	3	2	3	3	4	1	2	4	3	2	2
[illegible]	FA	PA	PA	RA	FA	GA	YA	KA	BA	FA	BA	TA	GA	WA	MA
[illegible]	4	2	2	2	2	2	3	3	1	1	1	3	2	2	2
[illegible]	NA	VA	YA	MA	KA	WA	BA	GA	FA	GA	DA	DA	VA	FA	DA
[illegible]	3	2	2	1	2	2	2	2	1	1	1	2	2	1	1
[illegible]	BA	BA	LA	PA	DA	DA	KA	LA	GA	KA	KA	FA	BA	KA	GA
2	2	1	1	1	1	1	2	2	1	1	1	2	1	1	1
KA	MA	DA	MA	TA	GA	PA	RA	BA	KA	LA	NA	MA	FA	MA	LA
1	2	1	1	1	1	1	2	1	1	1	1	2	1	1	1
LA	RA	GA	RA	VA	MA	SA	VA	DA	LA	NA	PA	BA	KA	PA	TA
1	2	1	1	1	1	1	2	1	1	1	1	1	1	1	1
RA	KA	TA	TA	WA	PA	TA	DA	NA	MA	PA	SA	NA	PA	BA	VA
1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
SA	VA	LA	VA	BA	RA	FA	FA	WA	DA	TA	WA	RA	DA	DA	BA
1	1	0	1	0	1	0	1	1	0	1	1	1	0	0	0
TA	WA	MA	WA	DA	VA	KA	PA	YA	PA	BA	MA	ZA	MA	GA	KA
1	1	0	1	0	1	0	1	1	0	0	0	1	0	0	0
VA	LA	RA	FA	LA	WA	LA	LA	RA	SA	MA	RA	KA	RA	LA	PA
1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
WA	PA	SA	KA	SA	BA	RA	SA	SA	TA	RA	VA	LA	SA	SA	RA
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DA	SA	WA	SA	YA	SA	VA	TA	VA	VA	WA	YA	PA	TA	VA	SA
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ZA	ZA	ZA	ZA	ZA	ZA	ZA	ZA	ZA	ZA	ZA	ZA	SA	ZA	ZA	WA
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3.3 Substitution errors ranked by frequency.

STIMULUS SYLLABLES

	DA	FA	GA	KA	LA	MA	NA	PA	RA	SA	TA	VA	WA	YA	ZA
0	TA .289	YA .273	NA .176	GA .389	NA .280	NA .364	WA .167	TA .250	YA .286	VA .167	GA .214	YA .233	YA .360	NA .313	NA .250
6	YA .158	KA .227	BA .118	FA .111	TA .160	YA .182	GA .125	MA .214	NA .238	YA .167	FA .143	WA .200	NA .200	RA .188	YA .188
52	GA .132	NA .136	DA .118	NA .111	YA .120	BA .091	MA .125	FA .107	WA .190	DA .083	LA .143	GA .133	LA .120	TA .125	FA .125
94	FA .105	PA .091	PA .118	RA .111	FA .080	GA .091	YA .125	KA .107	BA .048	FA .083	BA .071	TA .100	GA .080	WA .125	MA .125
A 94	NA .079	VA .091	YA .118	MA .056	KA .080	WA .091	BA .083	GA .071	FA .048	GA .083	DA .070	DA .067	VA .080	FA .063	DA .063
A 63	BA .053	BA .045	LA .059	PA .056	DA .040	TA .045	KA .083	LA .071	GA .048	KA .083	KA .071	FA .067	BA .040	KA .063	GA .063
A 031	MA .053	DA .045	MA .059	TA .056	GA .040	PA .045	RA .083	BA .036	KA .048	LA .083	NA .071	MA .067	FA .040	MA .063	LA .063
LA 031	RA .053	GA .045	RA .059	VA .056	MA .040	SA .045	VA .083	DA .036	LA .048	NA .083	PA .071	BA .033	KA .040	PA .063	TA .063
RA 031	KA .026	TA .045	TA .059	WA .056	PA .040	DA .045	DA .042	NA .036	MA .048	PA .083	SA .071	NA .033	PA .040	BA .000	VA .063
SA 031	VA .026	LA .000	VA .059	BA .000	RA .040	FA .000	FA .042	WA .036	DA .000	TA .083	WA .071	RA .033	DA .000	DA .000	BA .000
TA 031	WA .026	MA .000	WA .059	DA .000	VA .040	KA .000	PA .042	YA .036	PA .000	BA .000	MA .000	ZA .033	MA .000	GA .000	KA .000
VA .031	LA .000	RA .000	FA .000	LA .000	WA .040	LA .000	LA .000	RA .000	SA .000	MA .000	RA .000	KA .000	RA .000	LA .000	PA .000
WA .031	PA .000	SA .000	KA .000	SA .000	BA .000	RA .000	SA .000	SA .000	TA .000	RA .000	VA .000	LA .000	SA .000	SA .000	RA .000
DA .000	SA .000	WA .000	SA .000	YA .000	SA .000	VA .000	TA .000	VA .000	VA .000	WA .000	YA .000	PA .000	TA .000	VA .000	SA .000
ZA .000	ZA .000	ZA .000	ZA .000	ZA .000	ZA .000	ZA .000	ZA .000	ZA .000	ZA .000	ZA .000	ZA .000	SA .000	ZA .000	ZA .000	ZA .000

CONDITIONAL PROBABILITY OF SUBSTITUTION

Table 3.5. Ranked conditional probabilities of substitution.

SUBSTITUTING SYLLABLES

DA	FA	GA	KA	LA	MA	NA	PA	RA	SA	TA	VA	WA	YA	ZA
GA .118	TA .143	KA .389	FA .227	TA .143	PA .214	MA .364	GA .188	YA .188	TA .071	DA .289	SA .167	VA .200	WA .360	VA .033
SA .083	BA .125	BA .250	PA .107	WA .120	NA .125	YA .313	BA .094	KA .111	MA .045	PA .250	FA .091	RA .190	RA .286	BA .000
TA .071	ZA .125	TA .214	NA .083	SA .083	ZA .125	LA .280	FA .091	NA .083	BA .031	LA .160	NA .083	NA .167	FA .273	DA .000
VA .067	KA .111	ZA .188	SA .083	PA .071	VA .067	ZA .250	SA .083	GA .059	DA .000	YA .125	WA .080	YA .125	VA .233	FA .000
ZA .063	PA .107	VA .133	LA .080	ZA .063	BA .063	RA .238	TA .071	DA .053	FA .000	VA .100	ZA .063	MA .091	ZA .188	GA .000
FA .045	DA .105	DA .132	TA .071	GA .059	TA .063	WA .200	YA .063	LA .040	GA .000	SA .083	GA .000	TA .071	MA .182	KA .000
MA .045	SA .083	NA .125	YA .063	RA .048	GA .059	GA .176	KA .056	VA .033	KA .000	ZA .063	KA .056	GA .059	SA .167	LA .000
NA .042	LA .080	MA .091	RA .048	BA .031	KA .056	BA .156	MA .045	BA .031	LA .000	GA .059	LA .040	KA .056	DA .158	MA .000
LA .040	VA .067	SA .083	WA .040	DA .000	DA .053	FA .136	NA .042	FA .000	NA .000	KA .056	BA .031	LA .040	NA .125	NA .000
PA .036	YA .063	WA .080	BA .031	FA .000	RA .048	KA .111	LA .040	MA .000	PA .000	FA .045	DA .026	PA .036	LA .120	PA .000
BA .000	RA .048	PA .071	DA .026	KA .000	LA .040	SA .083	WA .040	PA .000	RA .000	MA .045	MA .000	BA .031	GA .118	RA .000
KA .000	NA .042	RA .048	GA .000	MA .000	FA .000	DA .079	DA .000	SA .000	VA .000	BA .031	PA .000	DA .026	BA .094	SA .000
RA .000	WA .040	FA .045	MA .000	NA .000	SA .000	TA .071	RA .000	TA .000	WA .000	NA .000	RA .000	FA .000	PA .036	TA .000
WA .000	GA .000	LA .040	VA .000	VA .000	TA .000	PA .036	VA .000	WA .000	YA .000	RA .000	TA .000	SA .000	KA .000	WA .000
YA .000	MA .000	YA .000	ZA .000	YA .000	WA .000	VA .033	ZA .000	ZA .000	ZA .000	WA .000	YA .000	ZA .000	TA .000	YA .000

Table 3.6, Stimulus syllables ranked, for each substituting syllable, by conditional probabilities.

ne column for each of the 16 stimulus syllables and the substituting yllables ranked by order of frequency of substitution within each olumn. A 2-step procedure was employed to eliminate the response bias that may arise through tendencies to omit certain syllables more han others, or to substitute particular syllables regardless of their trace strength' in memory at the time of recall.

The first step was to divide each raw score by the total umber of substitutions for that syllable (Table 3.5). In the second tep, the stimulus syllables were ranked for each substitution yllable using the conditional probabilities from Table 3.5. That s, the columns now display (Table 3.6), for each substituting syllable, he most frequent stimulus syllable eliciting that particular substitution, hen the next most frequent stimulus syllable, and so on to the stimulus yllable which elicits the particular substitution syllable for that olumn least often. This procedure equates the response bias across yllables.

In order to determine whether or not phonemic similarity nfluences substitutions, it is necessary to have an independent measure f the degree of similarity or difference between syllables. Since the owel /ɑ/ was phonemically (if not phonetically) the same in all cases, t was assumed that the similarity between syllables can be expressed s the similarity between their initial consonant phonemes. Phonemic imilarity was defined in terms of the distinctive feature system roposed by Wickelgren (1966) in which each consonant is uniquely escribed by reference to four dimensions - binary Voicing (voiced/unvoiced) nd Nasality (nasal/non-nasal) dimensions, a 3-valued dimension of Openness narrow, medium and wide), and a 5-valued Place of Articulation dimension ranging from 0 = bilabial to 4 = velar (/k/, /g/).

Table 3.7 shows the description of the 16 stimulus consonants n terms of this feature system.

Pairs of consonants were compared for the number of features hich served to contrast them. Thus, minimally-distinct pairs of onsonants such as /b/ and /p/, or /d/ and /t/, have only one contrastive eature whilst, at the other end of the scale of similarity, /n/ and /s/, nd /p/ and /r/, differ by 4 con trastive features.

The observed rank orders of substitution (from Table 3.6) were hen compared with the rank orderings which would be predicted by the ypothesis that the most frequent substitutions will involve pairs of yllables whose initial consonants differ by only 1 contrastive feature, ith substitution frequences decreasing as the number of contrastive eatures increases from 1 to 4. Each substituting syllable was onsidered separately, and the number of contrastive features serving o distinguish that syllable from each of the 15 possible stimulus yllables which it might replace was determined. For example, the yllable PA differs from the syllables BA, FA, TA, and KA by 1 contrastive eature, from DA, GA, MA, SA, VA, and WA by 2 contrastive features, and rom LA, NA, RA, YA, and ZA by 3 contrastive features. Thus, the predicted frequency rankings for the stimulus syllables which PA might replace in a substitution error are BA, FA, TA, KA, > DA, GA, MA, SA, VA, WA > LA, NA, RA, YA, ZA.

For PA, a total of 74 binary predictions can be made and compared against Table 3.3. For example, the prediction that KA would be substituted for PA more often than LA would be substituted for the same syllable was confirmed by their respective conditional probabilities

DISTINCTIVE FEATURES

Consonant	Voicing	Nasality	Openness	Place
b	1	0	0	0
d	1	0	0	1
f	0	0	1	0
g	1	0	0	4
k	0	0	0	4
l	1	0	2	2
m	1	1	0	0
n	1	1	0	1
p	0	0	0	0
r	1	0	2	1
s	0	0	1	2
t	0	0	0	1
v	1	0	1	0
w	1	0	2	0
y	1	0	2	3
z	1	0	1	2

Table 3.7. Distinctive feature analysis of 16 stimulus consonants used in Experiment III.

rom Table 3.6 (KA = .056, LA = .040). However, the analysis of ontrastive features predicts WA as a more frequent stimulus syllable han LA for the substitution of PA whereas their conditional robabilities are equal (both .040). Tied cases neither confirm nor isconfirm binary predictions, so the percentage of successful redictions was calculated as :-

$$\%\ \text{Correct prediction} = \frac{N_c}{N - N_t} \times 100$$

Where:

N = Total number of binary predictions (= 1120)

N_c = Number of confirmed predictions (= 628)

N_t = Number of ties (= 167)

The percentage of correct predictions obtained by this rocedure was 66%, which is significantly better than the 50% value hich would be expected if phonemic similarity played no part in etermining substitution errors ($\chi^2 = 96.3$, df = 1, $p < .001$). hus, for a sample of unambiguous consonant substitution errors which xcludes all possible transpositions (including repetitions) and erial order intrusions, there is a significant tendency for the ubstituting consonant to be phonemically similar to the consonant hich it replaces.

3.14. DISCUSSION.

The results of Experiment III show an effect of distinctive eature similarity on substitution errors and therefore indicate that onrad's (1964) comparable finding for letter sequences was not due solely to the inclusion of repetitive transpositions or serial order ntrusions in his matrix. The failure to obtain a higher rate of orrect prediction may be due to a loss of information between resentation and recall bringing about an attenuation of the similarity ffect. Alternatively, it may be possible to devise alternative eature systems which yield consistently better rates of prediction cf. e.g. Klatt, 1968) through being closer to the psychological imensions of encoding.

.15. GENERAL DISCUSSION.

Viewed purely as investigations of short-term memory, xperiments I - III have demonstrated three distinct effects of phonemic imilarity upon immediate recall errors. These effects are 1) that onsonant phonemes which are similar in terms of their component istinctive (phonetic) features are more likely to transpose within equences than are dissimilar phonemes, and 2) are also more likely o be involved in substitutions from outside the stimulus sequence both effects of intrinsic feature similarity), and 3) that consonant honemes accompanied by identical vowels are more likely to transpose han are consonants accompanied by different vowels (the contextual imilarity effect). It is characteristic of earlier studies that hey have failed to distinguish clearly between these three separable ffects.

Viewed in the light of the error equivalence hypothesis, hese experiments provide corroborative support for the claim that ransposition and Spoonerisms, and substitutions and segmental eplacements, constitute different surface manifestations of the same et of error-prone processes ascribable to a phonemic Response Buffer f the sort proposed in Sections 2.1 to 2.3.

CHAPTER 4.

SPOONERISMS AND TRANSPOSITIONS: THE EFFECTS OF SYLLABLE POSITION.

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EXPERIMENT IV[1]

.1. INTRODUCTION.

Chapter 3 was successful in taking predictions drawn from the tudy of natural Spoonerisms and testing them on transposition errors in hort-term memory. This Chapter will report further experiments in the ame vein, deriving predictions from the known effects of syllable osition on phonemic Spoonerisms and testing those predictions in mmediate recall situations.

Nooteboom (1967, 1969) and Boomer and Laver (1968) observed hat when phonemes exchange in a Spoonerism, the origin and target honemes tend strongly to have occupied the same position in their espective syllables. MacKay (1970) confirmed these observations with n analysis of 124 German Spoonerisms published by Meringer and Mayer 1895) and Meringer (1908). The syllabification of words was etermined from a contemporary German dictionary. In MacKay's study, onsonants were assigned to one of four possible syllabic positions; nitial position, next to initial, next to final, and final position for example, in the monosyllabic word stand, /s/ occurs in initial osition, /t/ in next to initial, /n/ in next to final, and /d/ in inal position: in tan, /t/ occurs in initial position and /n/ in inal). Vowels were assigned to one of three syllabic positions; nitial as in apt, mid-position as in bit, and final position as in o. Analysis of the Spoonerisms revealed that reversed consonants ccurred in the same syllable position in 98 per cent of errors, and eversed vowels originated in the same syllable position in 81 per ent of errors.

[1] Experiment IV represents a re-analysis of an experiment first reported y Ellis and Myers (1976).

If the error equivalence hypothesis holds, transpositions in short-term memory should also show an effect of syllable position. Experiment IV was designed to look for such an effect and involved the immediate recall of visually-presented lists of 5 syllables. There were two conditions, differing in their syllabic structure. Each list in the MIXED CONDITION contained a mixture of consonant-vowel (CV) and vowel-consonant (VC) syllables, thus testing two syllable positions for the consonants (syllable-initial and syllable-final) and two positions for the vowels (pre-consonant and post-consonant). The design of the lists made it possible to determine accurately the chance levels for transpositions involving pairs of phonemes originating in the same syllable position and pairs originating in different syllable positions. The error equivalence hypothesis predicts that transpositions of phonemes originating in the same syllable positions will occur at greater-than-chance frequencies. This prediction is embodied in Hypotheses 1 and 2:

Hypothesis 1. In the MIXED CONDITION, transpositions of consonants from initial origin positions to initial error positions, and from final origin positions to final error positions, will occur at greater-than-chance frequencies (and, hence, transpositions from initial to final and final to initial positions will occur at less than chance frequencies).

Hypothesis 2. In the MIXED CONDITION, transpositions of vowels from pre-consonant to pre-consonant positions, and from post-consonant to post-consonant positions, will occur at greater-than-chance frequencies and, hence, transpositions from pre-consonant to post-consonant and ost-consonant to pre-consonant positions will occur at less than chance requencies).

Hypotheses 1 and 2 embody the predictions of the error quivalence hypothesis which were tested in Experiment IV. However, a second experimental condition (the ALL-SAME CONDITION) was included to test the predictions of a more specific theory of the processes underlying the generation of Spoonerisms and transpositions. In Chapter 3 it was shown how feature similarity affects both types of error. The likelihood of exchange between two phonemes increases as the number of distinctive feature values which they share in common increases. Put differently, the extent to which two phonemes avoid exchanging with one another varies with the number of contrastive or discriminative features which serve to distinguish them. Now, such discriminative features need not be restricted to phonetic distinctive features: syllable position could also act as a discriminative feature with individual phonemes coded for their syllabic position as they are coded for voicing, nasality, or place of articulation. If this were the case, syllable position would serve as a functional discriminative feature to help differentiate consonants and vowels in sequences of mixed CV and VC syllables, but would not distinguish consonants and vowels in sequences of all CV or all VC syllables. That is, transposition errors would be expected to be less frequent in lists of mixed CV and VC syllables than in lists of all CV or all VC syllables (as were presented in the ALL-SAME CONDITION). Hypothesis 3 states this prediction.

Hypothesis 3. Transpositions of consonants and vowels will be more frequent in the ALL-SAME CONDITION than in the MIXED CONDITION.

4.2. METHOD.

There were two conditions in the experiment - an ALL-SAME CONDITION and a MIXED CONDITION. An independent subjects (or between subjects) design was used, with subjects being randomly assigned to one of the two conditions.

4.2.1. DESIGN.

a) ALL-SAME CONDITION.

The stimuli for this condition were 20 lists of 5 syllables per list. In 10 lists all the syllables were of the consonant-vowel (CV) order, while in the remaining 10 lists the syllables were of vowel-consonant (VC) order. 8 consonant letters (b, d, g, k, l, p, v, and z) and 5 vowel letters (a, e, i, o, and u) were used to form the syllables. Lists were devised according to the following constraints:-

i) No consonant or vowel was repeated within a list.

ii) Each vowel occurred twice at each serial position in the 10 CV lists and twice at each serial position in the 10 VC lists.

iii) Each consonant occurred either once or twice at each serial position in the 10 CV lists, and either once or twice at each serial position in the 10 VC lists.

iv) Each of the 80 possible syllables which can be derived from 8 consonants and 5 vowels in CV or VC order was used either once or twice in the 20 stimulus lists.

Examples of stimulus lists from the ALL-SAME CONDITION are:

1.	CV order:	de	pi	gu	lo	va
2.	VC order:	ab	ed	oz	uv	ip

The CV and VC lists were randomly interleaved in the presentation order.

b) MIXED CONDITION.

The stimuli for this condition were 20 lists of 5 syllables per list, comprising all possible permutations of 2 CV and 3 VC syllables, or 3 CV and 2 VC syllables, presented in a randomised order. The same 8 consonant letters and 5 vowel letters were used as in the ALL-SAME CONDITION. The constraints were similar to those of the ALL-SAME CONDITION, being:-

i) No consonant or vowel was repeated within a list.

ii) Each vowel occurred twice at each serial position in VC syllables.

iii) Each consonant occurred 2 or 3 times at each serial position, and an approximately equal number of times in CV and VC syllables.

iv) Each of the 80 possible syllables was used either once or twice in the 20 stimulus lists.

Examples of stimulus lists from the MIXED CONDITION are:-

1. gi ad el ku so

2. ob ul da me ig.

4.2.2. Subjects.

36 subjects performed the experiment, 18 in each condition. All were students of the University of Edinburgh, Department of Psychology, and all were unpaid volunteers.

4.2.3. Apparatus.

The syllables were presented visually at a rate of 3 syllables per 2 seconds (0.67 secs. per syllable), by means of a Forth Instruments SM memory drum. Lower case letters were used. These were taken from Blick dry print 14 pt. medium (letter height 2 - 3 mm.). Subjects' spoken responses were recorded on tape using a PYE CAMBRIDGE tape recorder with a 3M cardioid microphone.

4.2.4. Procedure.

Subjects were tested individually. The following written instructions were given:-

'In this experiment you will be asked to read silently lists of 5 syllables and then speak them aloud in the order in which they were presented. The syllables in each list will appear one at a time at the window of the memory drum in front of you . The fifth syllable will be followed by a zero which is your cue to repeat all 5 syllables aloud. After 16 seconds the small light on top of the memory drum will flash on and off to indicate that the next list is about to begin'.

The subject was then shown 30 sample syllables on a blackboard. Pronunciation of the vowel letters was left to the subject with the requirement that the 5 vowels should be clearly differentiated, and that each vowel letter should be pronounced the same way at each occurrence. A few minutes practice was given with the subject saying aloud syllables pointed to by E. 6 Practice lists were then given on the memory drum. During the course of the practice lists subjects were instructed to guess a syllable if unsure, or to say 'blank' at the appropriate point in the sequence if the syllable had been forgotten completely.

The 20 stimulus lists of either the ALL-SAME or the MIXED CONDITION were then given. Syllables were presented at a rate of 3 per 2 seconds, and the recall cue (zero) followed the fifth syllable at the same rate. 16 seconds were allowed for spoken, ordered recall.

A small white light fixed on top of the memory drum was flashed on and off 2 seconds before the start of the next list. Presentation and recall of the 20 stimulus lists lasted 6 minutes 40 seconds.

The subject's spoken responses were noted by E., seated behind and to the left of the subject, during the experiment. The session was also tape recorded to provide a check on E.'s transcription.

4.3. RESULTS.

4.3.1. Scoring.

An error was scored as a consonant transposition if i) a given (target) consonant in the stimulus list was replaced in the response list by a different (error) consonant which was presented in the stimulus list at a different (origin) position, and if ii) the vowel paired with the target consonant in the stimulus list accompanied the error consonant at recall (i.e. was correctly recalled).

Similarly, an error was scored as a vowel transposition if i) a given (target) vowel in the stimulus list was replaced in the response list by a different (error) vowel which was presented in the stimulus list at a different (origin) position, and if ii) the consonant paired with the target vowel in the stimulus list also accompanied the error vowel at recall.

An error was scored as a syllable transposition if a consonant-vowel pair, presented as a single syllabic item in the stimulus list, was recalled as a unit at a different serial position in the response list (it was not necessary for the original consonant-vowel order to be retained).

In order that the serial position might be unambiguously assigned to errors, only 5-item response sequences were scored ('blank' could count as an item). Errors which could be classed as serial rder intrusions of syllables from the same serial position in the receding response list were not scored as transpositions.

.3.2. ALL-SAME CONDITION.

In the ALL-SAME CONDITION, there are two forms of consonant ransposition - transpositions of consonants in lists of CV syllables syllable-initial, or i:i) and transpositions of consonants in lists of C syllables (syllable-final, or f:f). Similarly, there are two forms f vowel transposition - transpositions between vowels in CV syllables post-consonant or cV:cV) and transpositions between vowels in VC yllables (pre-consonant or Vc:Vc). Syllable transpositions can occur ither between CV syllables or between VC syllables.

321 consonant transpositions were scored at an average of 17.8 er subject. There were 150 i:i transpositions and 171 f:f transpositions this difference was not significant by the Wilcoxon matched-pairs igned-ranks test ($N = 14$, $T = 43$, $p < .05$, n.s. - Siegel, 1956).

128 vowel transpositions were scored at an average of 7.1 per ubject. The difference between the frequencies of cV:cV transpositions $N = 69$) and Vc:Vc transpositions ($N = 59$) was not significant $N = 14$, $T = 52.5$, n.s.).

100 syllable transpositions were scored. The difference etween transpositions of CV syllables ($N = 39$) and VC syllables ($N = 61$) as not significant ($N = 14$, $T = 29.5$, n.s.).

.3.3. MIXED CONDITION.

In the MIXED CONDITION, consonants can transpose between yllable-initial positions (i:i) and syllable-final positions (f:f), s in the ALL-SAME CONDITION, and also from initial to final position i:f), or from final to initial position (f:i). The MIXED CONDITION sed all 20 possible permutations of 2CV + 3VC or 3CV + 2 VC syllables.

Taking any pair of serial positions, the 20 lists afforded 4 opportunities for i:i transpositions, 4 for f:f, 6 for i:f, and 6 for f:i. Thus, the chance levels for the four types of consonant transpositions between any pair of serial positions and, therefore, for the lists as a whole are i:i and f:f 20 per cent, and i:f and f:i 30 per cent.

213 consonant transpositions were scored. Table 4.1. shows the distribution of these across the 4 classes of consonant transposition, together with the frequencies expected by chance. Hypothesis 1 predicted that i:i and f:f consonant transpositions would occur at greater-than-chance frequencies. To test this, the chance frequencies of i:i and f:f transpositions were computed individually for each subject at 40 per cent of the total number of consonant transpositions of syllable-initial origin (i:i + i:f) or syllable-final origin (f:f + f:i) for that subject. A Wilcoxon matched-pairs signed-ranks test (Siegal, 1956) was then used to compare, for each subject, the observed frequences of i:i or f:f transpositions against their respective chance levels. For both i:i and f:f transpositions, observed frequencies were significantly greater than chance levels, corroborating Hypothesis 1 (for i:i, $N = 18$, $T = 20$, $p < .005$, 1-tailed; for f:f, $N = 17$, $T = 3$, $p < .005$, 1-tailed).

Whilst Hypothesis 1 is borne out by the results, the data can be made to yield more specific information concerning the mechanism underlying the syllable position effect. Taking consonant transpositions of initial origin ($N = 102$) first, 43 consonants replaced other initial target consonants and, of these, the actual error (response) consonant was initial in 41 cases (95.3%) and final in only 2 cases (4.7%). This difference is highly significant ($N = 18$, $T = 0$, $p < .01$, 2-tailed).

	CONSONANT		TRANSPOSITIONS	
	i : i	f : f	i : f	f : i
BSERVED REQUENCY	65	75	37	36
HANCE	42.6	42.6	63.9	63.9

able 4.1. Observed and chance frequencies for each of the four pes of consonant transposition int the MIXED CONDITION Experiment IV).

The remaining 59% of consonants of initial origin transposed to target syllables whose own original (stimulus) consonant was syllable-final. Of these, the error consonant was initial in 24 cases (40.7%) and final in 35 cases (59.3%). This difference was not significant (N = 18, T = 60, n.s.). Thus, when a consonant of initial origin replaces an initial target consonant in a transposition error, the error consonant in the response is almost invariably syllable-initial also. However, when the target consonant is syllable-final, it is as if the influences of the initial coding of the transposing consonant and the final coding of the target were equally strong, producing approximately equal numbers of initial and final error consonants. The overall result is of a greater number of consonants of initial origin retaining their initial position in the error than chance would predict.

The same holds true, mutatis mutandis, of transposing consonants of syllable-final origin (N = 111). 67 replaced other final target consonants and, of these, the error consonant was final in 58 cases (86.6%), and initial in only 9 cases (13.4%). This difference is highly significant (N = 15, T = 0, $p < .005$, 1-tailed). The remaining 44 consonants transposed to syllables whose original target consonant was syllable-initial. Of these, the error consonant was final in 17 cases (38.6%) and initial in 27 cases (61.4%) - this difference was not significant (N = 15, T = 35.5, n.s.).

Vowel transposition in the MIXED CONDITION can also be of four types. Vowels can transpose between post-consonant positions (cV : cV) or between pre-consonant positions (Vc : Vc), as in the ALL-SAME CONDITION, and also from post-consonant to pre-consonant position (cV : Vc) or from pre-consonant to post-consonant position (Vc : cV). Taking any pair of serial positions (and thus for the 20 lists as a whole), the chance levels for the four types of vowel transpositions are cV : cV and Vc : Vc 20 per cent, and cV : Vc and Vc : cV 30 per cent.

171 vowel transpositions were scored. Table 4.2 shows the distribution of these across the 4 classes of transpositions, together with the frequencies expected by chance.

Hypothesis 2 predicted that cV : cV and Vc : Vc vowel transpositions would occur at greater-than-chance frequencies. To test this, the chance frequencies of cV : cV and Vc : Vc transpositions were computed individually for each subject as 40 per cent of the total number of vowel transpositions of post-consonant origin (cV : cV + cV : Vc) or pre-consonant origin (Vc : Vc + Vc : cV) for that subject. A Wilcoxon test was then used to compare, for each subject, the observed frequencies of cV : cV or Vc : Vc transpositions against their respective chance levels. For both cV : cV and Vc : Vc transpositions, observed frequencies were significantly greater than chance levels, corroborating Hypothesis 2 (for cV : cV, $N = 17$, $T = 31.5$, $p < .025$, 1-tailed; for Vc : Vc, $N = 17$, $T = 0$, $p < .005$, 1-tailed).

As with the consonant transpositions, a more detailed analysis is revealing. Taking vowel transpositions of post-consonant (cV) origin ($N = 93$), 40 vowels replaced other post-consonant target vowels and, of these, the error vowel was post-consonant in 35 cases (87.5%) and pre-consonant in only 5 cases (12.5%). This difference is highly significant ($N = 14$, $T = 6.5$, $p < .005$, 1-tailed).

	VOWEL	TRANSPOSITIONS		
	cV : cV	Vc : Vc	cV : Vc	Vc : cV
;ERVED :QUENCY	52	53	41	25
ANCE	34.2	34.2	51.3	51.3

ble 4.2. Observed and chance frequencies for each of the ır types of vowel transposition in the MIXED CONDITION. :xperiment IV).

The remaining 53 vowels of post-consonant origin transposed to target syllables whose origin vowel was pre-consonant (Vc). Of these, the error vowel was post-consonant in 17 cases (32.1%) and pre-consonant in 36 cases (67.9%), which represents a significantly greater frequency of pre-consonant errors ($N = 14$, $T = 8$, $p < .01$, 2-tailed). Thus, when a vowel of post-consonant origin replaces a post-consonant target vowel in a transposition error, the error vowel in the response shows a strong tendency to be also post-consonant. However, when a target vowel is pre-consonant, the influence of the target position is apparently stronger than that of the origin position producing more pre-consonant than post-consonant errors. This last effect is not as strong as when origin and target positions are the same.

Once again, the transpositions of vowels of pre-consonant (Vc) origin produce comparable results. Of the 78 such transpositions, 50 vowels replaced other pre-consonant targets, producing 47 post-consonant errors (94%) and 3 pre-consonant errors (6%). This difference is highly significant ($N = 16$, $T = 0$, $p < .005$, 1-tailed). The remaining 28 vowels of pre-consonant origin transposed to target syllables whose origin vowel was post-consonant (cV). Of these, the error vowel was pre-consonant in 6 cases (21.4%) and post-consonant in 22 cases (78.6%), which represents a significantly greater frequency of post-consonant errors ($N = 10$, $T = 3.5$, $p < .01$, 2-tailed). As with the vowel transpositions of post-consonant origin, when origin and target syllable positions are different, it is the target position which tends to determine the error outcome.

88 syllable transpositions were scored. Syllables showed a strong tendency to maintain their correct CV or VC order on

transposing. There were 43 transpositions of CV origin, 36 of which (i.e. 84%) maintained their correct CV order in the error ($N = 15$, $T = 3$, $p < .01$, 2-tailed). Of these 36, 15 (42%) replaced CV target syllables while 21 (58%) replaced VC target syllables ($N = 14$, $T = 33$, n.s.). There were 45 transpositions of VC origin, 43 of which (i.e. 96%) maintained their correct order in the error ($N = 15$, $T = 0$, $p < .01$, 2-tailed). Of these 43, 19 (44%) replaced VC target syllables while 24 (56%) replaced CV target syllables ($N = 14$, $T = 40.5$, n.s.). Thus, although the component consonants and vowels of syllables, when transposing separately, are influenced by the syllable position of the target they replace, transposing syllables are apparently unaffected by whether the position to which they transpose was occupied in the stimulus list by a syllable of the same CV or VC order or by one of a different order.

.3.4. COMPARISON OF ALL-SAME AND MIXED CONDITIONS.

There were 321 consonant transpositions in the ALL-SAME CONDITION and 213 in the MIXED CONDITION. This difference was just significant by the Mann-Whitney U-test (Siegel, 1956 : $n_1 = n_2 = 18$, $U = 109$, $p = .05$, 1-tailed) providing some support for Hypothesis 3. There was no significant difference between the frequencies of vowel transpositions in the two conditions (128 in the ALL-SAME CONDITION, 171 in the MIXED CONDITION, $n_1 = n_2 = 18$, $U = 144$, n.s.), nor was there any significant difference in the frequencies of syllable transpositions (100 in the ALL-SAME CONDITION, 88 in the MIXED CONDITION, $n_1 = n_2 = 18$, $U = 133$, n.s.).

.4. DISCUSSION.

Hypothesis 1 was supported; that is, syllable-initial onsonants tended to transpose with other syllable-initial consonants ather than with syllable-final consonants, and conversely. ypothesis 2 was also supported, that is pre-consonantal vowels ended to transpose with other pre-consonantal vowels rather than ith post-consonantal vowels, and conversely. For both consonant nd vowel transpositions, the origin position of the tranposing honeme and the target position of the displaced phoneme both xerted an influence upon the syllable position adopted by the error honeme in the final response. There was no tendency for whole yllables to transpose with other syllables of like structure. his replicated a result obtained by Wickelgren (1965b) using aural resentation of 6-syllable lists, and indicates that the syllable tructure constraint applies to the component phonemes of the yllabic units, rather than to the units themselves.

There was some evidence for a reduction in the frequency of onsonant transpositions when syllabic position acted as a iscriminative cue, but no evidence for any comparable reduction in owel transpositions. If this result is reliable, one could devize ome explanation as to why consonants should have more discriminative eatures than vowels (there being more of them, both in the phoneme nventory of the language and in most utterances), but such an ad hoc roposal would require more empirical support than the marginally-ignificant result obtained here.

In Experiment IV no difference was observed between the requencies of initial : initial and final : final consonant transpositions in either condition. This might appear to constitute evidence against the error equivalence hypothesis since MacKay (1970) found that Spoonerisms between initial consonants were considerably more frequent than between final consonants. However, Nooteboom (1967) restricted the comparison of initial : initial and final : final consonant transpositions to errors involving consonants in monosyllabic words of the form CVC. 49 errors of this sort were found, of which 26 involved syllable-initial consonants and 23 involved syllable-final consonants. Although this is a small sample, it is probably more closely comparable to the stimuli used in Experiment IV, and shows no significant difference between syllable-initial and syllable-final consonant transpositions. The discrepancy with MacKay's (1970) findings remains unreconciled (MacKay does not give the relative frequencies of initial and final consonants in the sample, which provides one possible explanation).

The chief finding, however, is that the error-equivalence hypothesis has once again been successful in predicting effects on short-term memory errors of a variable (syllable position) which had hitherto only been shown to influence naturally-occurring speech errors.

EXPERIMENT V.

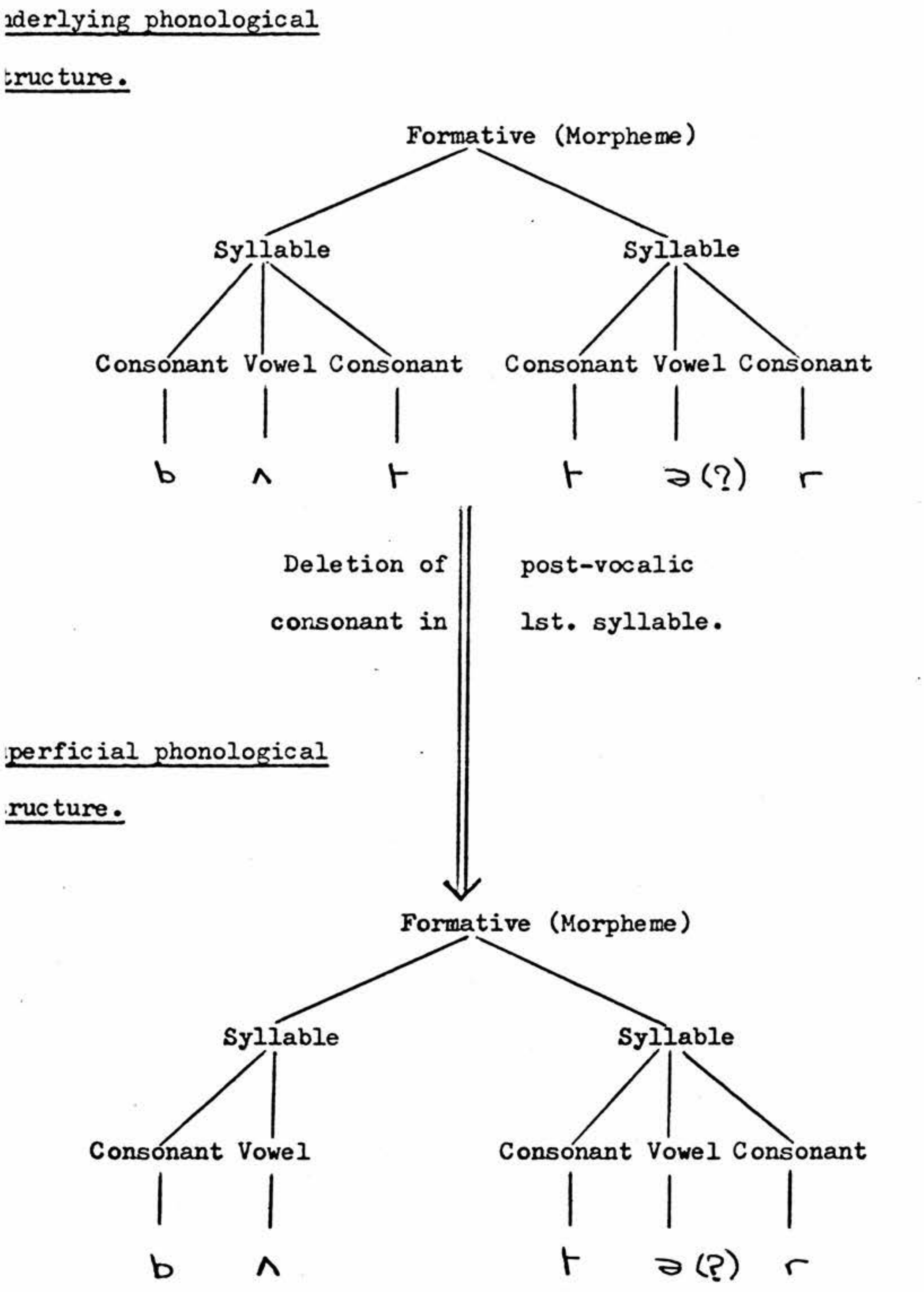
4.5. INTRODUCTION.

Experiments I to IV have sought to demonstrate that the same phonemic Response Buffer mediates both spontaneous speech production and phonemic short-term memory. If this claim is accepted, then short-term memory techniques may be used to supplement the analysis of natural speech errors in the study of speech production. Experiment V is an attempt to illustrate this role of the short-term memory experiment.

The question at issue in Experiment V is how the Response Buffer treats intervocalic consonants in VCV sequences occurring within words (or morphemes). In the course of a critique of syllabic phonology, Kohler (1966) argued that when a phoneme like /t/ can occur in both word-initial and word-final positions (e.g. <u>tea/eat</u>), the syllabic division of a word like <u>butter</u> was indeterminable and, therefore, impossible. Anderson (1969), in a discussion of Kohler's (1966) criticisms, proposed that the medial /t/ of butter is syllable-initial at the level of 'superficial (phonological) structure' (i.e. /bʌtər/ → /bʌ+tər/), but is derived from two /t/s in the 'underlying phonological structure' (/bʌt+tər/) by deletion of the post-vocalic consonant in the first syllable (see Figure 4.1).

Other linguists have adopted a rule whereby medial consonants in VCV sequences are treated as syllable-initial. For example, in a discussion of syllable demarcation in Modern Israeli Hebrew, Marbé, (1972:87), follows the principle that, 'One intervocalic consonant will be deemed to be a releasing consonant' (i.e. VCV V + CV). A speech synthesis-by-rule program expounded by Whitten (1975) divides phoneme sequences into syllables according to an algorithm which includes the rule: 'If two syllables have one intervening consonant, it belongs to the second'.

If the Response Buffer is organised along the lines of Anderson's (1969) 'superficial phonological structure' - that is, if it allocates intervocalic (intra-morphemic) consonants to the second syllable in accordance with the rules of Marbé (1972), Whitten (1975) and others - then intervocalic consonants should behave like syllable-initial consonants and transpose with them rather than with



gure 4.1. 'Underlying'and 'superficial' phonological structures
the -VCV- sequence in "butter" (after Anderson, 1969).

yllable-final consonants. If, on the other hand, some other principle f organization is adopted (e.g. Anderson's (1969) 'underlying honological structure'), then no such tendency should be present.

Experiment V investigated the transpositional tendencies of onsonants in VCV sequences by embedding such sequences in lists of ixed CV and VC syllables which provided equal opportunities for the ntervocalic consonant to transpose with either syllable-initial or yllable-final consonants. The experiment also permitted a replication f Experiment IV as regards the effect of syllable position on consonant ransposition between simple CV and VC syllables.

.6. METHOD.

.6.1. Design.

The experimental stimuli were 2 sets (Set A and Set B), each f 16 stimulus lists. Each set was devized as follows:-

) There were 5 items in each list. The 3rd. item was always a VCV trigram while items 1, 2, 4 and 5 comprised all 16 possible permutations of 0-4 CV syllables and 4-0 VC syllables.

i) The vowel letter was always 'e'.

ii) 8 consonant letters were used (b, d, f, k, p, s, v and z). Each consonant occurred twice as the central consonant of the VCV trigram at serial position 3, and twice at each of the serial positions 1, 2, 4 and 5 (once in a CV syllable and once in a VC syllable).

Examples of the stimulus lists used are:-

1.	fe	es	eke	ve	ed
2.	ek	ed	ese	pe	ez

This arrangement of items provides equal numbers of CV and C syllables at each of the serial positions 1, 2, 4 and 5, thus llowing equal opportunities for the intervocalic consonant of the VCV o transpose with other consonants of either syllable-initial or yllable-final position. For any of the pairs of serial positions and 2, 4 and 5, 2 and 4, 1 and 4 and 2 and 5, and thus for the stimulus ists as a whole, there are equal opportunities for consonant ranspositions from initial to initial positions (i : i), and final o final (f : f), initial to final (i : f), and final to initial (f : i).

.6.2. Subjects.

12 subjects took part in the experiment. All were students f the University of Edinburgh, Department of Psychology, and all were npaid volunteers.

.6.3. Apparatus.

Stimuli were presented visually by means of a Forth Instruments M memory drum. The stimuli were typed in lower-case letters. Subjects' poken responses were recorded on tape using a PYE CAMBRIDGE tape ecorder with a 3M cardioid microphone.

.6.4. Procedure.

Subjects were tested individually. The subject was first iown the set of 24 syllables and trigrams on a blackboard and was taught › pronounce each item with the vowel /e/ as in pet, men. 6 practice ists were then given on the memory drum.

The 16 lists of each set were randomized for presentation to ie subjects. The items were presented at a rate of one per second. ie subject read each item aloud on presentation. The fifth item was llowed at the same rate by an asterisk which was the subject's cue to peat all 5 items in their correct order. Subjects were instructed to iess wherever possible if they were unsure, otherwise to say 'blank'

; the appropriate position in the sequence. 22 seconds were allowed r spoken, ordered recall before a small white light fixed on top of e memory drum indicated that the next list would begin in 2 seconds.

6 subjects were given the 16 stimulus lists of Set A, lasting minutes, followed by 5 minutes rest, then the 16 lists of Set B sting a further 8 minutes. The remaining 6 subjects were given t B first and Set A second.

The subjects' spoken responses were transcribed by E. who sat hind and to the left of the subject. The responses were also tape corded to provide a later check on E.'s transcription.

7. RESULTS.

All transpositions were scored except those which could be nstrued as serial order intrusions of items from the same serial sition of the preceding response list.

7.1. Transpositions among serial positions 1, 2, 4 and 5.

Transpositions between items at serial positions 1, 2, 4 and (that is, transpositions not involving the central VCV item) behaved a manner closely similar to the consonant transpositions in periment IV. Details are shown in Table 4.3.

There were 131 transpositions of initial origin. 74 replaced itial targets and 57 replaced final targets: this difference was gnificant ($N = 12$, $T = 11.5$, $p < .01$, 1-tailed). Of the 74 ansp ositions of initial origin which replaced initial targets, ! (84%) resulted in syllable-initial errors and only 12 (16%) in llable-final errors ($N = 12$, $T = 0$, $p < .005$, 1-tailed). In contrast, the 57 transpositions of initial origin which replaced final targets, (44%) resulted in initial errors and 32 (56%) in final errors: is difference was not significant ($N = 8$, $T = 7.5$, n.s.). Overall, ere were significantly more transpositions from initial origins to

INITIAL ORIGIN			
INITIAL TARGET		FINAL TARGET	
Initial error	Final error	Initial error	Final error
16	12	25	32

FINAL ORIGIN			
INITIAL TARGET		FINAL TARGET	
Initial error	Final error	Initial error	Final error
31	27	6	83

Table 4.3. Origin, target, and error position of consonant transpositions between serial positions 1, 2, 4 and 5 in Experiment IV.

initial error positions (a total of 87) than to final error positions (a total of 44; $N = 11$, $T = 0$, $p < .005$, 1-tailed).

There were 147 transpositions of final origin. 91 replaced final targets and 58 replaced initial targets: this difference was significant ($N = 11$, $T = 4.5$, $p < .005$, 1-tailed). Of the 91 transpositions of final origin which replaced final targets, 83 (91%) resulted in syllable-final errors and only 6 (9%) in syllable-initial errors ($N = 11$, $T = 0$, $p < .005$, 1-tailed). In contrast, of the 58 transpositions of final origin which replaced initial targets, 27 (67%) resulted in final errors and 31 (33%) in initial errors: this difference was not significant ($N = 10$, $T = 25$, n.s.). Overall, there were significantly more transpositions from final origins to final error positions (a total of 110) than to initial error positions (a total of 37 - $N = 10$, $T = 0$, $p < .005$, 1-tailed).

As in Experiment IV, there was no significant difference between syllable-initial and syllable-final positions as origins of transposition errors ($N = 12$, $T = 30.5$, n.s.), or between transpositions from initial origins to initial error positions (i : i) and transpositions from final origins to final error positions (f : f - $N = 12$, $T = 23.5$, n.s.).

4.7.2. Transpositions involving the intervocalic consonant at serial position 3.

165 transpositions involving the intervocalic consonant at serial position 3 were scored. 89 of these were transpositions of consonants from syllables at serial positions 1, 2, 4 and 5 into the intervocalic position and 76 were transpositions of the consonant from serial position 3 away from the intervocalic position and into one of the other syllables of the list.

Considering first the 89 transpositions of consonants into the intervocalic position from other serial positions, 40 of these (45%) came from syllable-initial origin positions and 49 (55%) from syllable-final origin positions. This difference was not significant (N = 7, T = 6.5, n.s.).

Turning to the 76 transpositions of the intervocalic consonant away from serial position 3, the target consonant was syllable-initial in 30 cases (39%) and syllable-final in 46 cases (61%). This difference just failed to achieve significance (N = 10, T = 9, n.s.). The 30 transpositions from intervocalic position to initial targets resulted in 17 initial errors and 13 final errors (N = 12, T = 25, n.s.). There was, however, a significant tendency for transpositions from the intervocalic position to final targets to adopt final error positions (36 errors) rather than initial error positions (10 errors - N = 10, T = 0, $p < .01$, 2-tailed).

.8. DISCUSSION.

The transpositions of consonants between CV and VC syllables n serial positions 1, 2, 4 and 5 showed a clear effect of syllable osition (initial consonants tending to transpose with initial consonants, nd final with final), thus replicating the results of Experiment IV. n contrast, the intervocalic consonants at serial position 3, showed no ignificant preference for initial or final target positions and were ot replaced by transposing consonants from initial origin positions ather than from final origin positions. The only significant effect as that intervocalic consonants transposing to syllables with final arget consonants tend to adopt final error positions (N.B. the influence f target position as well as origin position on error distribution was hown in Experiment IV).

There is, therefore, no evidence that a general rule of the orm VCV→ V + CV operates at the level of the Response Buffer (indeed, ne nonsignificant tendency was in the opposite direction to that xpected if such a rule was observed). The results are compatible ith the Response Buffer being organised along the lines of Anderson's 1969) 'underlying phonological structure', or with Greenberg's (1962) roposal that intervocalic consonants may belong to two syllables imultaneously (i.e. be coded as both post-vocalic and pre-vocalic). he failure to reject a Null Hypothesis cannot, however, be taken as ositive supporting evidence for the 'psychological reality' of either f these alternatives.

The rule rejected here is not the same as the rule for ividing an utterance into 'articulatory syllables' as defined by ozhevnikov and Chistovich (1965). An 'articulatory syllable' by his theory is a vowel plus as many consonants as immediately preceded t (the structure Co-nV), therefore, according to Kozhevnikov and histovich, <u>all</u> consonants in speech are initial consonants of articulatory syllables'. Nooteboom (1967) interpreted this theory as redicting that when the second consonant of a CVC form is immediately ollowed by an initial vowel of the next word, that consonant might be xpected to be involved in Spoonerisms with other consonants of clearly nitial origin (e.g. word-initial consonants). Such errors, however, ccur very infrequently (none were found in Nooteboom's corpus); the ord-final consonants in question tending instead to exchange with ther word-final consonants.

5.9. GENERAL DISCUSSION.

It is a widespread problem in psycholinguistics that forms at a number of different linguistic levels are correlated in their distribution so that it is often difficult to say which of a set of correlated variables is responsible for an observed effect. So far, we have not questioned whether the effects attributed to syllable position are, in fact, due to that variable.

Garrett (1975: 141, fn.6.) observes that the data on phonemic Spoonerisms 'do not really seem to distinguish between a syllable structure constraint, on the one hand, and the joint effects of constraints on word (or morpheme) position and the vowel /consonant identity of exchanged elements, on the other', (one might add a third constraint on permissible phoneme sequences, namely a phonotactic constraint). However, the CV and VC items presented as stimuli in Experiments IV and V are <u>syllables</u> although very few are <u>words</u> or <u>morphemes</u>, and yet syllable position clearly constrains the pattern of observed transpositions between the consonants and vowels of these items. If it is assumed that the processes underlying Spoonerisms and transpositions are the same, then an explanation in terms of syllable structure constraints seems justified.

Syllables, as Kent (1976 : 88) remarks, 'are both troublesome and attractive in the development of models of speech production'. Linguists have variously defined syllables as the appropriate domain of phonotactic rules (O'Connor and Trim, 1953; Fudge, 1969, Marbé, 1972) or other phonological rules (see Introduction to Fromkin, 1973a : 18), as rhythmic units carrying linguistic stress (Abercrombie, 1964; O'Connor, 1973), or as phonetic units relating to articulatory or acoustic phenomena.

learly, a distinction is required between on the one hand the honological syllable as a unit in a phonological hierarchy between maller phonemic segments and larger units such as the foot and tone-group Halliday, 1967, O'Connor, 1973) and, on the other hand, a possible honetic syllable as an articulatory or acoustic unit. It is the honological syllable which is proposed as a relevant unit at the level f the Response Buffer (the phonological syllable may be related to the honetic syllable through the intermediary of rules which translate a honemic (syllabic) sequence into neuromuscular commands - see romkin, 1968; Kent, 1976). However, there is no necessary one-to-one elationship between phonological and phonetic syllables, and evidence or or against the 'psychological reality' of one does not affect the elevance of the other. Thus, the 'articulatory syllable' of Kozhevnikov nd Chistovich (1965), rejected as a unit at the level of the Response uffer, may still be a relevant unit for the description of myodynamic erformance, (although MacNeilage (1972) and MacNeilage and Ladefoged (1976) iscuss problems relating to the co-articulatory phenomena upon which the oncept of the articulatory syllable was based). Also, the nconclusive studies of co-articulation in VCV sequences (Öhman, 1966; utcher and Weiher, 1976) are more relevant to the articulatory phonetic evel than the phonological level of the Response Buffer.

CHAPTER 5.

STRESS LEVEL, SPOONERISMS, AND TRANSPOSITIONS.

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5.1. GENERAL INTRODUCTION : STRESS AND SPOONERISMS.

MacKay (1971) analysed 124 within-word Spoonerisms from the German corpus of Meringer and Mayer (1895) and Meringer (1908). These errors all involved the reversal of phonemes within single words. For each pair of reversed phonemes, an intruding phoneme was defined as the anticipated phoneme executed before its correct place in the utterance. A lagging phoneme was defined as the phoneme executed after its correct time in the sequence. Syllables were designated either stressed or unstressed by reference to a contemporary German dictionary. Now, since only one syllable per word is stressed in German, and since all the Spoonerisms analyzed occurred within words, there was no possibility of discovering interactions between pairs of phonemes each from stressed syllables in this corpus. Three possibilities remain:

i) The intruding phoneme originates in a stressed syllable and the lagging phoneme in an unstressed syllable. Such errors were termed instances of stress pre-entry (e.g. example 1 - capital letters denote stressed syllables).

(1) beGAbung ⟶ gebabung

ii) The intruding phoneme originates in an unstressed syllable and the lagging phoneme in a stressed syllable. Such errors (e.g. the hypothetical example 2) were termed instances of stress-post entry.

(2) * beGAbung ⟶ bebagung

iii) Both the intruding phoneme and the lagging phoneme originate in unstressed syllables.

MacKay (1971) found that stress pre-entry accounted for 71 per cent of the Spoonerisms, stress post-entry for 11 per cent, and interactions between unstressed syllables for 18 per cent. The relative frequencies of stressed and unstressed syllables in correctly-produced sentences from Meringer suggested chance levels for these 3 error types as 23 per cent, 51 per cent, and 26 per cent respectively. That is to say, stress pre-entry Spoonerisms predominated at greater-than-chance frequencies while stress post-entry errors and interactions between unstressed syllables were relatively infrequent. A similar preponderance of stress pre-entry errors was found in a corpus of American within-word Spoonerisms taken from Bawden (1900).

MacKay (1971) acknowledged that stress per se might not be the cause of these observed regularities. One alternative possibility he countenanced was that "in natural speech, stressed syllables and words are more informative (in the information-theory sense) than unstressed ones, so that this may be why they enter before their time" (MacKay: 1971:39). To test this possibility, MacKay employed a form of short-term memory experiment (this at a time when most psychologists would have attributed the effects he observed to an acoustic Primary Memory system - cf. Chapter 1). MacKay (1971) had subjects repeat 20 times the syllable sequence 'tay gay bay day' under 5 stress conditions. In the no-stress condition, the subjects were instructed not to emphasise any of the syllables. In the remaining four conditions, one of the syllables was stressed (made louder than the others). Spoonerisms were defined as reversals (e.g. TAY gay bay day → TAY bay gay day). By chance, only 40 per cent of the reversals should involve a stressed syllable, whereas in fact, 51% of the reversals involved a stressed syllable ($p < .05$ by the chi-square one-sample test). Furthermore, 90 per cent of the reversals involving a stressed syllable were instances of stress pre-entry (cf. chance 50%). MacKay (1971) concluded that the stress pre-entry phenomenon applied to isolated syllables as well as to connected discourse and therefore that it is a function of the stress of the syllables per se, rather than some other, correlated variable such as informational content.

MacKay (1971: 49 fn.7) notes that, "Analysis of between-word Spoonerisms showed a slightly different (sic) pattern of stress. Of the between-word reversals in Meringer's corpus 97% occurred in syllables that were both stressed, an outcome exceeding chance expectation at the .01 level, chi-square test." This finding is much more compatible with the reports by other investigators of the link between stress and Spoonerisms. For example, Boomer and Laver (1968) analyzed tape recorded slips of the tongue in English. Syllables in the recorded utterances were designated either <u>salient</u> (stressed) or <u>weak</u> (unstressed) within the rhythmic unit of the <u>foot</u> (Abercrombie, 1964). Boomer and Laver summarised their finding in the form of a statistical 'law' stating that, "The origin syllable and the target syllable are metrically similar, in that both are salient, or both are weak, with salient-salient pairings predominating". Similar results are reported by Nooteboom (1967) and Garrett (1975).

EXPERIMENT VI.

5.2 INTRODUCTION.

The results of Nooteboom (1967), Boomer and Laver (1968) and Garrett (1975) imply a <u>same stress level effect</u> whereby phonemes from syllables which are either both stressed or both unstressed interact. This effect might hold for between-word Spoonerisms, whilst the stress pre-entry effect might characterise within-word slips (the greater relative frequency of between-word Spoonerisms than within-word Spoonerisms might then be invoked to explain why most investigators only report the 'like-with-like' effect).

Either the same stress level effect or the stress pre-entry effect, or both, might be a consequence of stress *per se*, equally either or both might be a consequence of correlated informational, semantic, or syntactic variables. The error equivalence hypothesis would predict analogous stress effects in short-term memory if, as MacKay's (1971) experiment suggests, one or both of these effects is attributable to the stress coding of elements within a phonemic Response Buffer, but not if higher- order variables are responsible.

Experiment VI had two conditions, both of which involved the immediate recall of lists of 5 visually-presented syllables. In the NO-STRESS CONDITION the subject read and recalled the syllables on a monotone. In the 2, 4-STRESSED CONDITION the subject stressed the second and fourth syllables in the sequence. A same stress level effect operating in the experiment would increase the proportion of transpositions between serial positions and 2 and 4 (both stressed) and serial positions 1 and 3, 3 and 5, and 1 and 5 (both unstressed) in the 2, 4-STRESSED CONDITION relative to the NO-STRESS CONDITION. In contrast, a stress pre-entry effect would increase the relative proportions of transpositions between serial positions 2 and 3, and 3 and 4, in the 2, 4-STRESSED CONDITION over the NO-STRESS CONDITION.

5.3. METHOD.

5.3.1. Design.

There were two conditions in the experiment, a NO-STRESS CONDITION and a 2, 4-STRESSED CONDITION. The stimuli for both conditions were lists of 5 consonant-vowel (CV) syllables, in which the vowel letter was always 'A' (to be pronounced /ɑ/ as in far, half) and the consonant letters were selected from a set of 16 (B, D, F, G, K, L, M, N, P, R, S, T, V, W, Y and Z).

2 sets of 20 lists were devized, each in accordance with the following constraints:-

i) No consonant was repeated within a list.

ii) No consonant occurred in successive lists.

iii) Each consonant occurred either once or twice at each of the serial positions 1 to 5.

A within-subjects design was employed with each subject performing in both conditions, (using different sets of lists in each condition). Equal numbers of subjects performed in each of the four possible combinations of 2 sets of lists and 2 orders of presentation of conditions.

5.3.2. Subjects.

16 subjects of the University of Edinburgh acted as subjects. All were unpaid volunteers.

5.3.3. Apparatus.

Stimuli were presented by means of a Forth Instruments SM memory drum. Subjects' spoken responses were recorded by means of a PYE CAMBRIDGE tape recorder fitted with a 3M cardioid microphone.

5.3.4. Procedure.

Subjects were tested individually. The lists of 5 syllables were presented visually, by means of a memory drum, at a rate of one syllable per second. The syllables were typed in capital (upper case) letters. A blank space recall cue followed the fifth syllable at the same rate. Subjects were instructed to read each syllable aloud as it was presented, and then to repeat all 5, in their correct order, when the blank space appeared. Subjects were asked to guess where possible, otherwise to say "blank" at the appropriate position in the sequence. In the NO-STRESS CONDITION, subjects read the syllables from the memory drum on a monotone at a normal speaking volume and recalled them in the same manner. In the 2, 4-STRESSED CONDITION, subjects emphasised the second and fourth syllables in each list both at presentation and recall. Emphasis involved speaking the stressed syllables (2 and 4) louder and at a higher pitch than the unstressed syllables (1, 3, and 5). 13 seconds were allowed for spoken, ordered recall. A small white light fixed on top of the memory drum was then flashed on and off to indicate that the next list would begin 2 seconds later. 8 Practice lists preceded each of the two conditions. A 5-minute rest period was allowed between conditions.

The subjects' spoken responses were noted during the experiment by E., seated and to the left of the subject. The responses were also recorded and E.'s transcription was subsequently checked against the recording.

5.4. RESULTS.

1037 syllables were recalled at their correct serial positions in the NO-STRESS CONDITION as compared with 878 in the

2, 4-STRESSED CONDITION. This difference was significant by the Wilcoxon matched-pairs signed-ranks test ($N = 14$, $T = 9.5$, $p < .01$, 2-tailed). Figure 5.1 shows the percentage of items correctly recalled at each serial position for the two conditions. It will be seen that the form of the stress pattern in the 2, 4-STRESSED CONDITION had no obvious effect upon the probability of correct recall other than a general decrement in performance across all serial positions in comparison with the NO-STRESS CONDITION.

Transposition errors were scored when a syllable was recalled at an incorrect serial position. 308 transpositions were noted in the NO-STRESS CONDITION and 370 in the 2,4-STRESSED CONDITION ($N = 16$, $T = 42.5$, n.s.). An analysis was also made of reversal errors, of which there were 68 in each condition, but the results only complement those obtained for transposition errors and will not be reported in detail.

The hypotheses under test refer to the proportions of transpositions occurring between various pairs of serial positions. Wilcoxon tests were used to compare, for each individual subject, the proportions (of the total number of transposition errors made by that subject) of transpositions occurring between particular pairs of serial positions. Table 5.1 gives full details of the results.

5.4.1. Same stress level hypothesis.

The same stress level hypothesis, derived from studies of naturally-occurring between-word Spoonerisms, predicts that in sequences of mixed stress and unstressed syllables, transpositions will tend to occur between syllables of like rather than unlike stress. That is, the hypothesis predicts an increase in the proportions of transpositions between serial positions 2 and 4 (both stressed) and

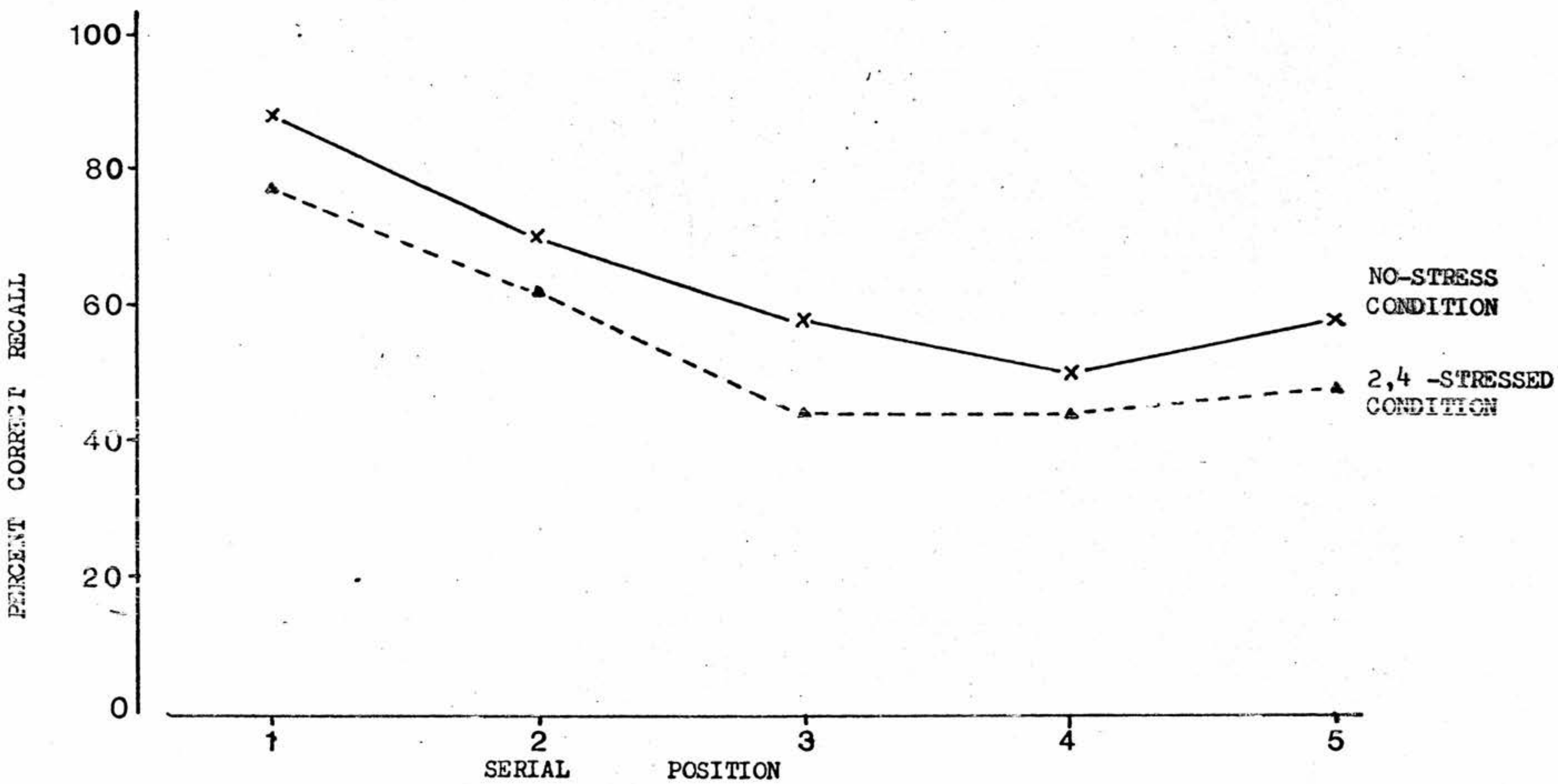

Figure 5.1. Percentage correct recall at each serial position in NO-STRESS and 2,4 -STRESSED CONDITIONS (Experiment VI).

			+ 1 = 5	+ 4 - 1	+ 2 - 5	+1 - 4 + 5 - 2
		STRESSED: STRESSED	UNSTRESSED: UNSTRESSED	STRESS PRE-ENTRY	STRESS POST-ENTRY	OTHERS
2,4 STRESSED CONDITION	FREQUENCY (N = 370)	36	61	64	65	144
	PERCENTAGE OF ALL ERRORS	9.7	16.5	17.3	17.6	38.9
NO - STRESS CONDITION	FREQUENCY (N = 308)	34	45	48	68	113
	PERCENTAGE OF ALL ERRORS	11.0	14.6	15.6	22.1	36.7
	N = 16, T = 42.4, n.s.	N = 13, T = 42, n.s.	N = 10, T = 12.5 n.s.	N = 15, T = 37 n.s.	N = 16, T = 63 n.s.	N = 15, T = 33.5 n.s.

Table 5.1. Analysis of transposition errors in Experiment VI.

1 and 3, 3 and 5, and 1 and 5 in the 2, 4-STRESSED CONDITION over the NO-STRESS CONDITION, with a corresponding decrease in the proportions of transpositions between other pairs of serial positions. The results, however, failed to support these predictions. In the 2, 4-STRESSED CONDITION 34 transpositions occurred between the stressed syllables at serial positions 2 and 4 (11.0% of all transpositions in that condition). In the NO-STRESS CONDITION, 36 transpositions (9.7% occurred between the same pair of serial positions). The difference in proportions was not significant (N = 15, T = 51.5, n.s.).

Similarly, there were 61 transpositions (16.5%) between unstressed syllables at serial positions 1, 3 and 5 in the 2, 4-STRESSED CONDITION, as compared with 45 transpositions (16.5%) between the same serial positions in the NO-STRESS CONDITION (N = 15, T = 48, n.s.).

5.4.2. Stress pre-entry hypothesis.

The stress pre-entry hypothesis, derived from MacKay's (1971) analysis of within-word Spoonerisms, predicts that in sequences of mixed stressed and unstressed syllables, transpositions will tend to involve phonemes originating in stressed syllables being anticipated before their correct position in the sequence, replacing phonemes from unstressed syllables. That is, the hypothesis predicts a higher proportion of transpositions from serial positions 2 to 1, 4 to 3 and 4 to 1 in the 2, 4-STRESSED CONDITION than in the NO-STRESS CONDITION. In fact, there were 64 anticipatory transpositions between the above-mentioned pairs of serial positions in the 2, 4-STRESSED CONDITION (17.3% of all transpositions in that condition) and 48 transpositions (15.6%) in the in the NO-STRESS CONDITION. The difference in proportions was not significant (N = 15, T = 44, n.s.).

5.5. DISCUSSION.

It is worthwhile at this stage to summarize the various reported observations on the interactions between stress and order errors in speech and short-term memory.

1) Nooteboom (1967), Boomer and Laver (1968), Garrett (1975) and others have all reported a "same stress level effect" whereby phonemic Spoonerisms between words tend to involve phonemes both of which originate in stressed syllables (or, less frequently, unstressed syllables). There is a strong tendency for one of the two stressed syllables to be the tonic syllable of the tone-group (see Section 2.3) with the other syllable being an earlier, salient but non-tonic syllable (Boomer and Laver, 1968).

2) According to MacKay (1971) within-word Spoonerisms tend to involve the anticipation of a phoneme from a stressed syllable, replacing a phoneme from an earlier, unstressed syllable. The replaced phoneme may, in turn, replace the anticipated phoneme at its correct position, resulting in a reversal of the two phonemes. This was termed the "stress pre-entry effect".

3) MacKay (1971) apparently replicated the stress pre-entry effect using rapid, multiple repeated recall of a 4-syllable sequence with one or none of the syllables stressed.

4) Experiment VI failed to produce either a same stress level effect or a stress pre-entry effect using a paradigm in which the subjects read aloud a sequence of 5 syllables, either on a monotone or stressing the second and fourth syllables, and then attempted a single, immediate recall of the sequence.

Doubts and questions can be raised concerning all of these observations. Thus, the predominance of Spoonerisms involving phonemes

a stressed syllable).

Several authors (e.g. Boomer and Laver, 1968; Fromkin, 1971, Introduction to 1973a; Garrett, 1975; and Cutler, 1977) have made an observation which is hard to reconcile with the idea of an intrinsic connection between prosody and slips. When phonemes exchange in Spoonerisms, their stress levels do not, as it were, transpose with them; rather the stress pattern of the utterance remains faithful to the intended utterance (this is also true of exchanges involving 'content words' - nouns, verbs, adjectives, etc.), but not exchanges of function words (Cutler, 1977). This observation is hard to reconcile with a model in which the indexical coding of phonemes for stress level in a pre-articulatory Response Buffer determines their order of selection for output, and hence their proneness to mutual exchange - on the contrary, this dissociability of segmental and suprasegmental aspects of an utterance is what one would expect if the two components were planned separately and in parallel, with the prosodic structure being superimposed on the phonemic sequence <u>after</u> the level of processing at which Spoonerisms occur.

If the latter account is true, then the 2,4-STRESSED CONDITION of Experiment VI may be interpreted as merely adding a second, concurrent task (maintaining a stress pattern) to the primary task of repeating the stimulus syllables accurately.(N.B. As with the naturally-occurring Spoonerisms, the stress pattern of the subjects' responses remained correct despite transposition of items within the list). This interpretation accords well with the retrospections of most of the subjects. When asked at the end of the experiment, only 2 subjects felt they had performed better in the 2,4-STRESSED CONDITION than in the NO-STRESS CONDITION; 5 subjects felt there was little, if any, difference, and 9 felt the NO-STRESS CONDITION was definitely easier. Typical comments from this last group (which support the present interpretation) were:-

Su. 8: "Perhaps the need to think about stressing meant that you tended to forget about the order ..... I expected stress to be helpful, but I don't think it was."

Su. 6: "I was concentrating too much on trying to put some sort of stress on than actually remembering."

Su. 4: "I felt as if I was trying to remember both a letter (i.e. a syllable) and a stress or no stress..... stress was a right pain."

If stress *per se* is not directly responsible for the distribution of between-word phonemic Spoonerisms, what is? A number of investigators have proposed that the *tertium quid* is to be found in the sorts of words that carry sentential stress. For example, Fodor, Bever and Garrett (1974) suggest that in the process of planning an utterance, content (stressed) words are selected first, and are therefore held in memory longer than function (unstressed) words, allowing more time for interference effects to introduce errors into the sequence. The obvious difficulty with this class of theory is that although it accounts for the tendency of Spoonerisms to occur between content words, it does not explain why it is the stressed syllables of those words which are particularly prone to error.

An alternative theory has to do with the rhythmic substructure of tone-groups which have been earlier proposed as marking successive outputs of the Response Buffer (c.f. Section 2.3.). According to the systemic theories of Abercrombie (1964) and Halliday (1967), stressed syllables divide up tone-groups into smaller rhythmic units termed 'feet' (a 'foot' consisting of a stressed syllable and as many unstressed syllables follow it up to the next stressed syllable). More recently, Rees (1975) has proposed a modification of the theory of 'isochronicity' in speech whereby stressed syllables within tone-groups tend to occur at roughly equal time intervals - this being achieved by lengthening or shortening of intervening unstressed syllables. Thus, feet become not only units of rhythmic structure, but also units of temporal structure (cf. Martin, 1972). Now, Ryan (1969) studied the effects of temporal grouping on transposition errors in the immediate recall of 9-letter sequences. She observed that when subjects were asked to group their responses into 3 groups of 3 letters each by pauses, the transpositions that occurred tended to involve the translocation of a letter from a particular position in one group to the same position in another group (cf. also Wickelgren, 1964) .

If syllables are subject to a form of temporal grouping in the Response Buffer, determined by the placement of stressed syllables, then Ryan's (1969) results may provide an experimental analogue of the same stress-level effect' for between-word (i.e. between-feet) spoonerisms if one adds the further postulate that, for speech, early phonemes in each foot are more prone to error than later phonemes. This is all highly speculative, but it is testable in so far as it predicts an influence of foot position on the (rare) exchanges involving pairs of unstressed syllables (N.B. it would take a considerable time to collect a sufficiently large corpus to test this prediction). Also, a modified immediate recall paradigm with syllables grouped temporally as well as by stress rhythm should, if the theory is correct and the error equivalence hypothesis valid, produce an experimental mimicking of the 'same stress-level effect'. For the moment, it is time to direct attention away from Spoonerisms and transpositions and towards another pair of errors for which equivalence is hypothesised, namely phoneme masking in speech and the Ranschburg Effect on short-term memory.

CHAPTER 6.

PHONEME MASKING AND THE RANSCHBURG EFFECT.

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6.1. GENERAL INTRODUCTION.

The varieties of short-term memory error discussed so far have typically been studied in the context of lists of items which are all different one from another. There exists, however, an error effect in short-term memory whose occurrence is specific to lists containing identical repeated items. This effect is known as the Ranschburg Effect (McGeoch, 1942; Obonai and Tatsumo, 1945; Jahnke, 1969, 1974), and may be defined as the tendency to omit or alter one of a pair of repeated items in a sequence. For example, the digit list 145259 may be misrecalled as 14529 by omission of the second 5, or as 145239 by substitution of the second repeated digit.

MacKay (1969) has reported a superficially similar phenomenon in spontaneous speech which he terms 'phoneme masking'. MacKay's examples were taken from the corpus of German speech errors published by Meringer and Mayer (1895) and Meringer (1908), and all involved only the omission of one of a pair of repeated phonemes as in example (1) below:

(1) Unglaublich ⟶ Unglaubich

Although MacKay (1969) studied only omission masking errors, examples (2) to (5) from the Appendix to Fromkin (1973a) demonstrate how repeated phonemes may also induce alteration (replacement) of one of the pair.

(2) I'm married almost 15 years ⟶ I'm barried ... married

(3) vogal gords ⟶ vogal gourds

(4) goofing off ⟶ gooping off

(5) San Bernadino ⟶ San Bermadino

Rather than regarding either the Ranschburg Effect or phoneme masking as distinct forms of error, it may be preferable to regard the two effects as providing contexts which strongly predispose the subject or speaker towards omission, substitution/replacement and possibly transposition/Spoonerism errors.

EXPERIMENT VII.

6.2. INTRODUCTION.

The purpose of Experiment VII was to demonstrate the existence of a phonemic Ranschburg Effect comparable to that already demonstrated for letters, digits, words etc. The design involved immediate recall of lists of 5 auditorily presented CV syllables. In the CONTROL CONDITION the consonants of the 5 syllables were all different whilst in the REPEATED CONSONANT CONDITION one consonant occurred twice in the sequence, at serial positions 2 and 4. A decrement in correct recall was predicted for the repeated items relative to their counterparts in the CONTROL CONDITION. This decrement should be specific to serial positions 2 and 4.

6.3. METHOD.

6.3.1. Design.

The stimuli were 20 lists of 5 consonant-vowel (CV) syllables, made up from the consonants / f, g, k, l, m, n, p and z / and the vowels a (= /æ/), e (= /e/), i (= /ɪ/), o (= /ɒ/) and u = /ʊ/).

There were 10 stimulus lists in the CONTROL CONDITION. The consonants and vowels were semi-randomly assigned to the syllables in the 5 serial positions of these lists in accordance with the following constraints:-

i) Each vowel occurred only once in each list, and twice at each serial position in the 10 stimulus lists.

ii) No consonant occurred more than once in a list. Each occurred once or twice at each serial position and 6 or 7 times altogether in the 10 lists.

iii) Each of the 40 possible CV syllables was used either once or twice in the 10 lists.

The 10 lists of the REPEATED CONSONANT CONDITION were derived from the lists of the CONTROL CONDITION. This was done for 5 of the REPEATED CONSONANT lists by replacing the consonant in the fourth syllable of a CONTROL list by the consonant from the second syllable of that list, for example:-

CONTROL list:	zi	ga	lo	mu	ne
REPEATED CONSONANT list:	zi	ga	lo	gu	ne

In the remaining 5 REPEATED CONSONANT lists, the consonant of the second syllable of a CONTROL LIST was replaced by the consonant from the fourth syllable of that list, for example:-

CONTROL list:	pa	me	ku	go	li
REPEATED CONSONANT list:	pa	ge	ku	go	li

Considering the 20 stimulus lists together, the following points applied:-

i) Each vowel occurred once per list and 4 times at each serial position.

ii) Each consonant was used 11 to 14 times (2 to 4 times at each serial position).

iii) Each of the 40 possible syllables was used 1 to 4 times in all. Real-word syllables (e.g. ma and pa) were restricted to serial 1, 3 and 5 so as not to differentiate between CONTROL and REPEATED CONSONANT lists.

The CONTROL and REPEATED CONSONANT lists were interleaved in the presentation order, ensuring that at least two lists separated a CONTROL list from its derived REPEATED CONSONANT list.

6.3.2. Subjects.

14 subjects performed the experiment. All were students of the University of Edinburgh, Department of Psychology, and all were unpaid volunteers.

6.3.3. Apparatus.

The stimuli were recorded on tape by means of a PYE CAMBRIDGE tape recorder fitted with a 3M cardiod microphone and played to the subject through EAGLE INTERNATIONAL headphones. The same equipment was used to record the subjects' spoken responses.

6.3.4. Procedure.

Subjects were tested individually. The stimulus syllables were recorded at a rate of 2 per second. A warning tone of 7 kc/sec. and 0.5 sec. duration preceded the first syllable by 2 seconds, and an identical recall tone followed 1 second after the fifth syllable of each list.

The subjects were instructed to repeat the syllables in their correct order, guessing if possible where unsure, otherwise saying 'blank' at the appropriate place in the sequence. 15 seconds were allowed for recall of each list. 6 Practice lists (3 CONTROL and 3 REPEATED CONSONANT lists) were given before the 20 experimental stimulus lists.

The subject's spoken responses were recorded on tape and also noted by E. during the course of the experiment (E. was seated behind and to the left of the subject). E.'s transcription was subsequently checked against the recording of the session.

6.4. RESULTS.

Scoring and analysis concentrated upon the consonants of the stimulus lists. An item recall score was used; that is, a stimulus consonant was scored as having been correctly recalled if it occurred at any position in the response sequence. In the REPEATED CONSONANT CONDITION, a repeated consonant recalled at serial positions 1 or 2 was assigned to the stimulus position 2; a repeated consonant recalled at positions 4 or 5 was assigned to stimulus position 4. If the repeated consonant was recalled only once, at serial position 3, it was assigned alternately to stimulus positions 2 and 4.

Figure 6.1 shows the serial position curves obtained in the two conditions, together with comparisons of the frequency of correct recall at each serial position by means of the Wilcoxon matched-pairs signed-ranks test (Siegel, 1956). The only significant differences between the CONTROL CONDITION and the REPEATED CONSONANT CONDITION occurred at serial positions 2 and 4 - the positions at which the repeated consonants occurred.

6.5. DISCUSSION.

The results clearly demonstrate the existence of a phonemic Ranschburg Effect using orthodox short-term memory procedures. The next step in the argument, pursued in Experiment VIII, is to propose error equivalence between the phonemic Ranschburg Effect and phoneme masking in speech, and to look for the effects on the former type of error of variables known to influence the latter.

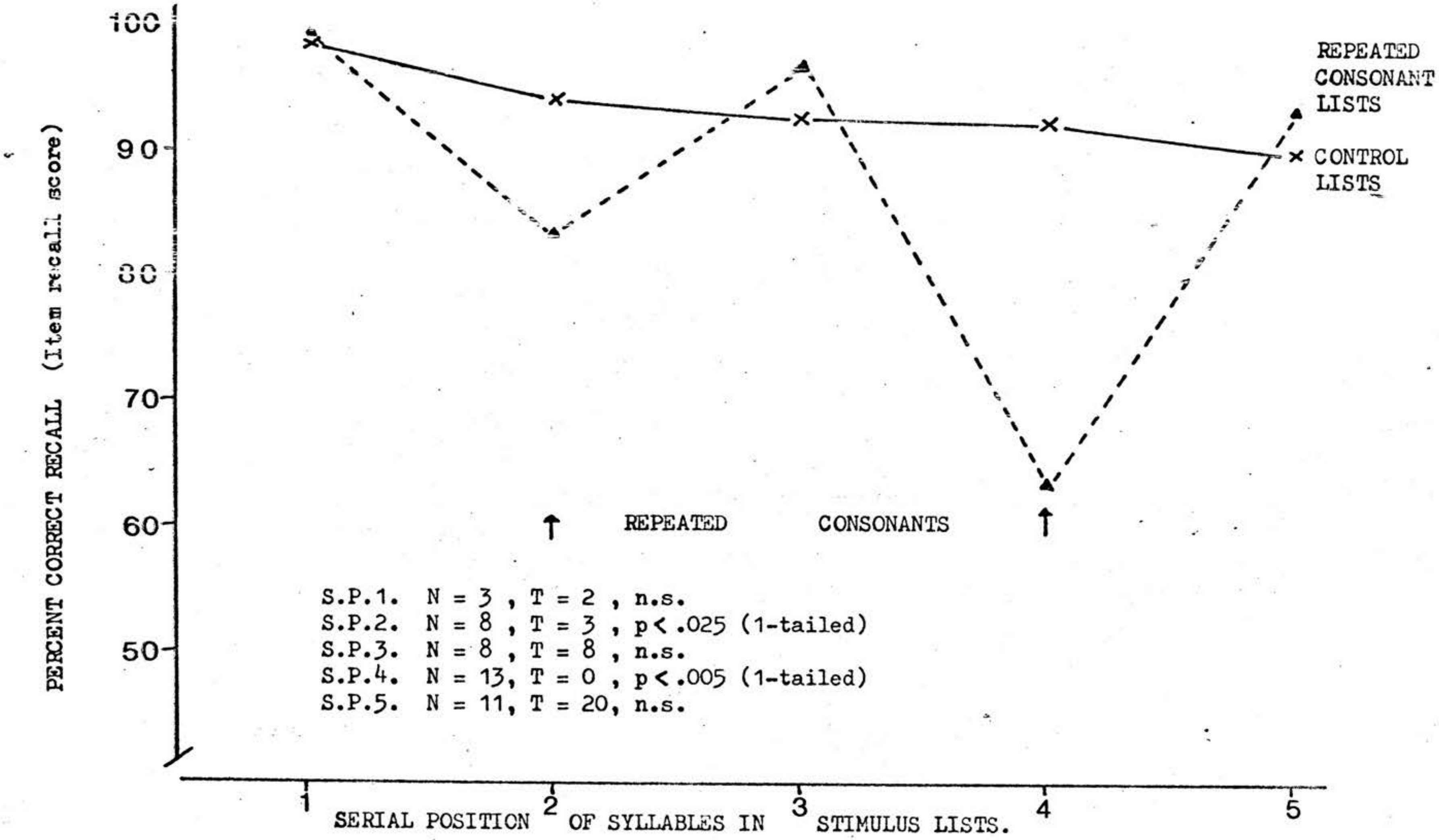

Figure 6.1. Percentage of consonants correctly recalled at each serial position in CONTROL and REPEATED CONSONANT lists (Experiment VII).

EXPERIMENT VIII.

6.6. INTRODUCTION.

When an equivalence between Spoonerisms and transpositions was first tentatively proposed, a survey of the relevant literatures supported the proposal by revealing several ways in which the two error forms appeared to behave similarly (Section 4.1.). In contrast, there is only one point in the literatures on phoneme masking and the Ranschburg Effect to which one can point in support of the proposed equivalence. MacKay (1969 : 58) reports that 'phonemes preceding or following the masked and masking phonemes differed in one or two distinctive features more frequently than would be expected by chance, but were identical or differed in all distinctive features less frequently than chance expectation'. Given that most, if not all, masking errors affect consonants, this implies that masking tends not to involve pairs of identical consonants which belong to syllables whose respective vowels are also identical. A seemingly comparable effect of contextual vowel similarity was reported for the Ranschburg Effect by Jahnke and Melton (1968) who found that the Ranschburg Effect failed to operate upon repeated consonant-letters in strings of 'acoustically-similar' (i.e. identical vowel) letters, although the normal effect occurred with low similarity (different vowel) strings.

Experiment VIII examines the effect of syllable position on the phonemic Ranschburg Effect. MacKay's (1969) analysis of phoneme masking in speech indicates that syllable position affects phoneme masking in much the same way as it affects phonemic Spoonerisms in that there is a tendency for the masked and masking phonemes to occupy the same position in their respective syllables. Experiment VIII follows Experiment VII in comparing recall performances between pairs of repeated consonants and pairs of nonrepeated (control) consonants in the 2nd. and 4th syllables of 5-syllable lists. The stimulus syllables are of either consonant-vowel (CV) or vowel-consonant (VC) structure, so that the pairs of critical consonants can occupy either the same position in their respective syllable, with both syllable-initial (CV : CV) or both syllable-final (VC : VC), or different positions with the first initial and the second final (CV : VC) or vice-versa (VC : CV). The error equivalence hypothesis predicts inhibition in recall of repeated consonants in CV : CV and VC : VC syllables but not in CV : VC or VC : CV syllables.

6.7. METHOD.

6.7.1. Design.

A) CONTROL LISTS. The stimuli in this condition were 32 lists of 5 consonant-vowel (CV) or vowel-consonant (VC) lists. 16 of the 20 possible permutations of 3CV and 2VC, or 2CV and 3VC syllables were employed[1], each permutation being used twice. This design gave 8 lists in which the second and fourth syllables of the list were both CV (the CV : CV CONTROL lists), 8 lists in which the second and fourth syllables were both VC (the VC : VC CONTROL lists), 8 lists in which the second syllable was CV and the fourth VC (the CV : VC CONTROL lists), and 8 lists in which the second syllable was VC and the fourth CV (the VC : CV CONTROL lists). There were 16 CV and 16 VC syllables at each serial position.

10 consonants were used (/b, d, f, g, k, l, m, n, p and z /) and 5 vowels (a [= /æ/], e [= /e/], i [= /ɪ/], o [= /ɒ/], and

(1) The permutations CV CV CV VC VC, CV CV VC VC VC, VC VC VC CV CV, and VC VC CV CV CV were not used.

u [= /ʌ/]. Consonants and vowels were assigned to syllables with the constraint that no consonant or vowel occurred more than once in any list.

<u>B) REPEATED CONSONANT LISTS.</u> The REPEATED CONSONANT (R.C.) Lists were derived from the CONTROL lists such that there were 8 CV : CV R.C. lists 8 VC : VC R.C. lists, 8 CV : VC R.C. lists and 8 VC : CV R.C. lists. 4 of the 8 R.C. lists in each of these subgroups were derived by replacing the consonant of the fourth syllable of a CONTROL list by the consonant of the second syllable in that list, for example:-

VC : VC CONTROL list	ob	i<u>m</u>	da	e<u>l</u>	gu
DERIVED VC : VC R.C. list	ob	i<u>m</u>	da	e<u>m</u>	gu

The remaining 4 R.C. lists of each subgroup of lists were derived by replacing the consonant of the second syllable of a CONTROL list by the consonant of the fourth syllable in that list, for example:-

VC : CV CONTROL list	fi	a<u>b</u>	ud	<u>p</u>e	ok
DERIVED VC : CV R.C. list	fi	a<u>p</u>	ud	<u>p</u>e	ok

The following regularities applied to all 64 syllable lists (32 CONTROL and 32 REPEATED CONSONANT lists):-

i) Each consonant occurred 6 to 8 times at each serial position and was used 30 to 33 times in all.

ii) Each vowel occurred 6 or 7 times at each serial position.

iii) Each consonant and vowel occurred an approximately equal number of times in CV and VC syllables.

iv) Each of the 100 possible syllables (10 consonants x 5 vowels x 2 orders) occurred 2 to 4 times. Meaningful (real-word) syllables were restricted to serial positions 1, 3 and 5.

than once in a list, thus 'p' may occur once as 'pi' and once as 'op', or 'k' may occur once as 'ik' and once as 'ak'.

Each of the 5 syllables is preceded by a warning tone like this ..... which tells you that a new list of syllables is about to begin. You will then hear the 5 syllables. At the end of the list you will hear a second tone. When you hear this tone, try to speak the syllables in the order in which you heard them, keeping as close as possible to the sound of the original syllables. If you are unsure of any of the syllables, please guess wherever possible - otherwise say 'blank' at the appropriate place in the sequence.

To help familiarize you with the type of list you will be hearing, here are two examples of typical lists with both the warning tone at the beginning and the recall tone at the end. First example:

ni ab ul fe mo

Second example:

ez pu di po ak

Your task, then, is to repeat the list in the correct order, either guessing or saying 'blank' if you are unsure. Do not attempt recall until you have heard the second tone. You will have 15 seconds to repeat the list before a warning tone indicates that the next list is about to begin. You will be given 6 practice lists before the 32 experimental lists which constitute the first half of the experiment. There will then be a rest period before the second set of 32 lists which complete the experiment. If you have any questions, please remove the headphones and ask them now.'

The experimental hypothesis, derived from MacKay's (1969) study of phoneme masking, predicted a specific decrement in recall for the repeated consonants of CV : CV R.C. lists and VC : VC R.C. lists relative to the corresponding pairs of syllables in their CONTROL list counterparts. This phonemic Ranschburg Effect was not expected to apply to the repeated consonants of CV : VC R.C. lists or VC : CV R.C. lists. CONTROL and R.C. lists were not expected to differ significantly at serial positions 1, 3 and 5.

Figures 6.2, 6.3, 6.4 and 6.5 show the serial position curves obtained with item recall scores for consonants in corresponding CONTROL and R.C. lists. For the VC : VC and VC : CV lists, Wilcoxon tests failed to reveal any significant differences between CONTROL and R.C. lists at any serial position. A significant decrement in recall, specific to the repeated consonants of the second and fourth syllables, occurred with the CV : CV lists and with the CV : VC lists. (There was a marginally-significant ($p = .05$, 2-tailed) recall decrement at serial position 5 with the CV : CV lists, but this result should be interpreted with caution in view of the large number of tests carried out).

6.9. DISCUSSION.

The results of Experiment VIII are distinctly anomalous. An effect of syllable position on the phonemic Ranschburg Effect was sought, and an effect was obtained. Unfortunately, however, the effect sought and the effect obtained are not the same. On the basis of MacKay's (1969) study of phoneme masking it was predicted that pairs of repeated phonemes sharing the same syllable position (i.e. both in CV syllables or both in VC syllables) would be prone

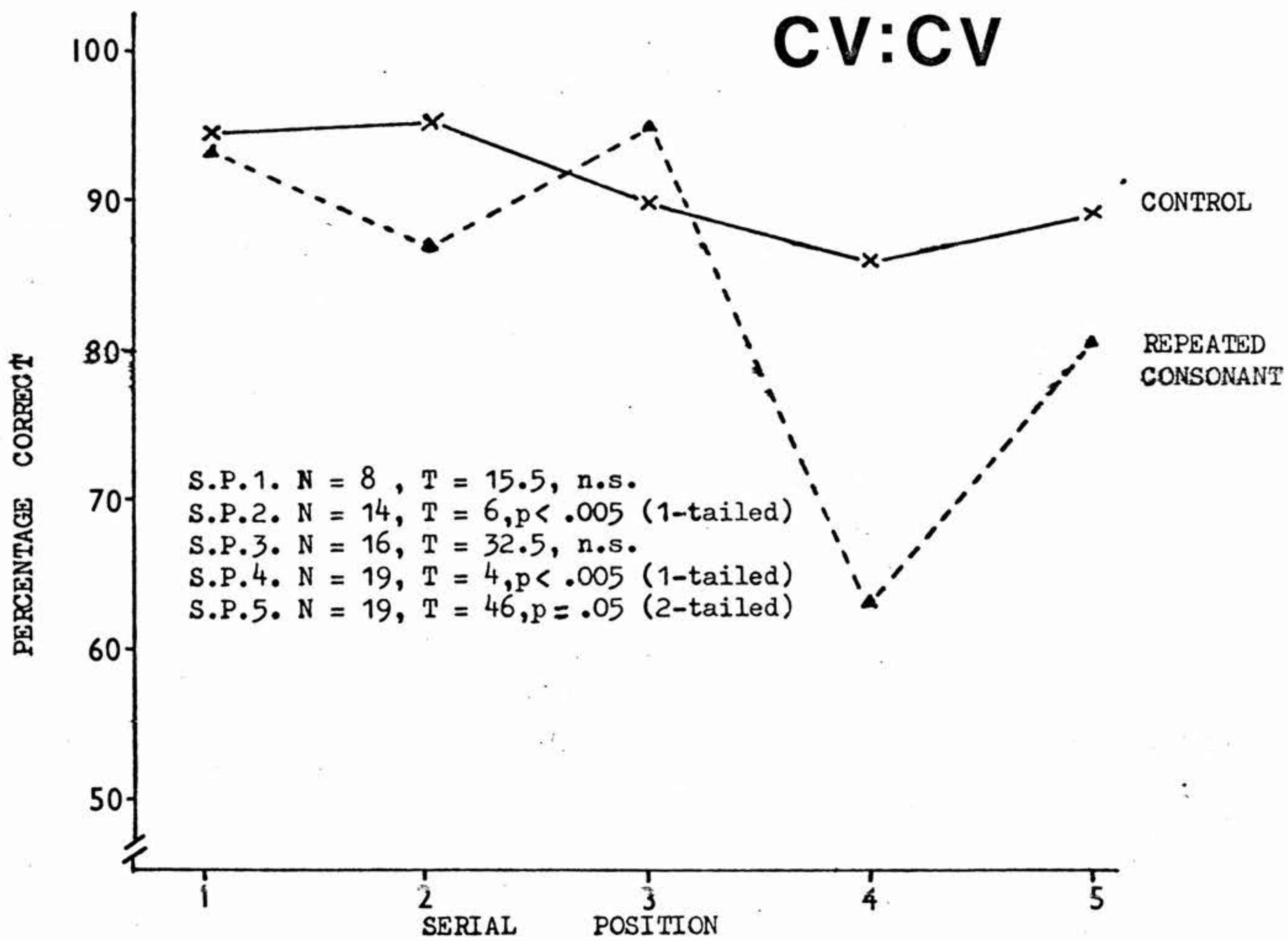

Figure 6.1. Item recall scores for consonants in CV:CV CONTROL and REPEATED CONSONANT lists (Experiment VIII).

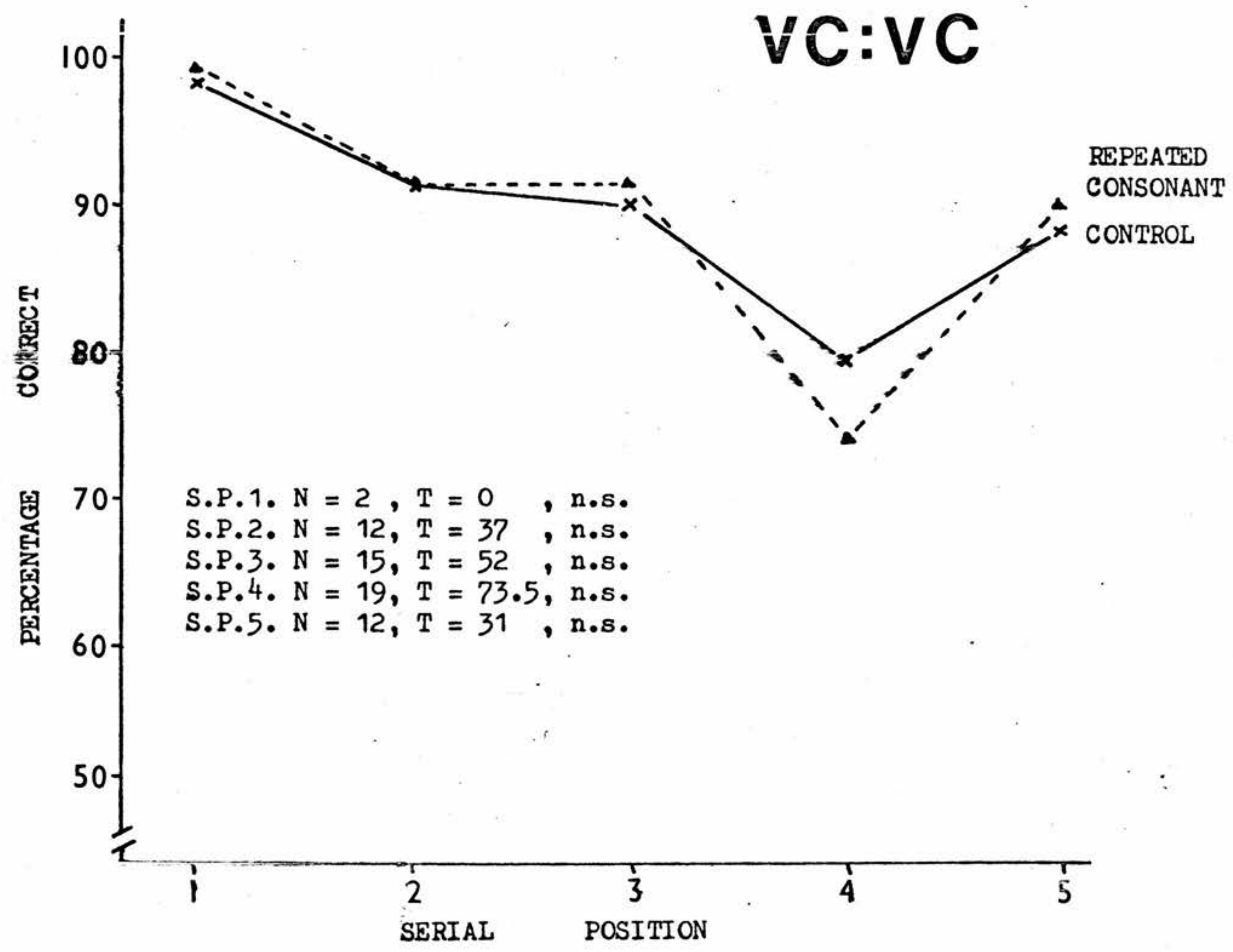

Figure 6.2. Item recall scores for consonants in VC:VC CONTROL and REPEATED CONSONANT lists (Experiment VIII).

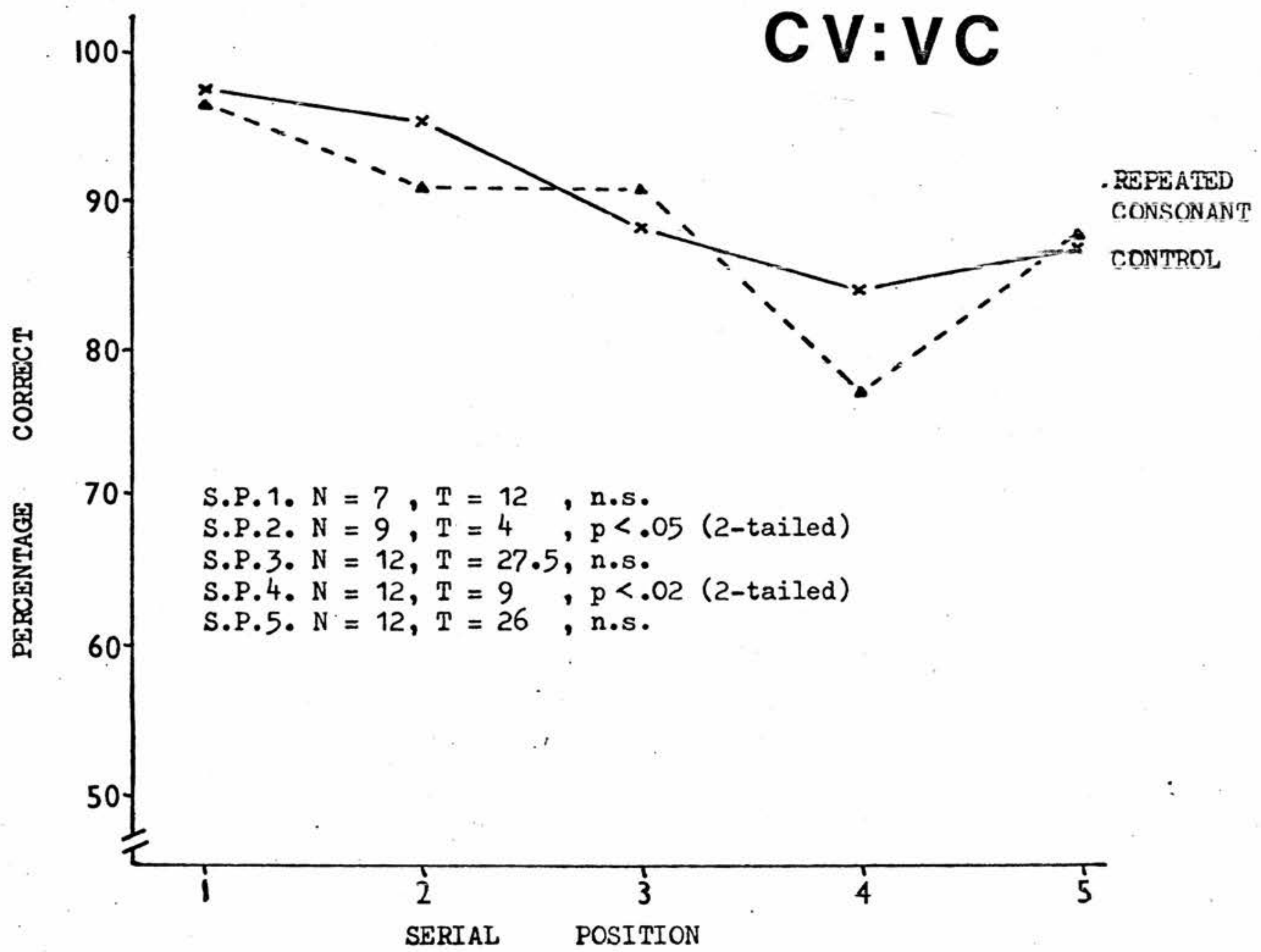

Figure 6.3. Item recall scores for consonants in CV:VC CONTROL and REPEATED CONSONANT lists (Experiment VIII).

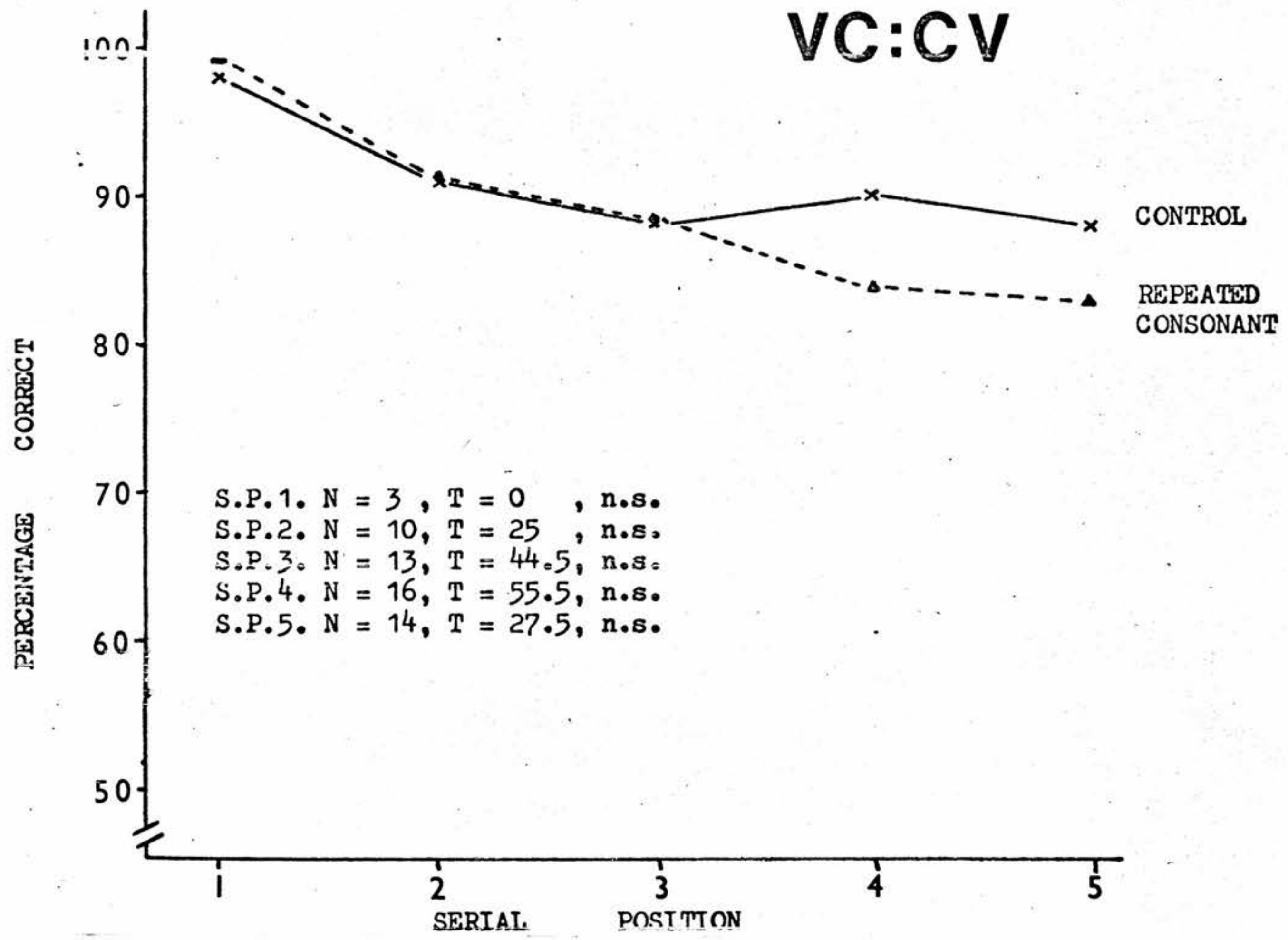

Figure 6.4. Item recall scores for consonants in VC:CV CONTROL and REPEATED CONSONANT lists (Experiment VIII).

to the phonemic Ranschburg Effect. The results, however, indicate that the effect applies to pairs of repeated syllable-initial consonants (the CV : CV lists) or pairs of repeated consonants in which the first occurrence is syllable-initial and the second occurrence is syllable-final (the CV : VC lists). Put differently, a pair of repeated consonant phonemes will exert a mutual inhibitory influence in immediate recall if the first phoneme is syllable-initial, regardless of the syllable position of the second member of the pair.

Faced with this apparent discrepancy between phoneme masking in speech and the phonemic Ranschburg Effect in short-term memory, three options present themselves. The first is to deny the applicability of the error equivalence hypothesis to phoneme masking and the phonemic Ranschburg Effect. A supporter of this contention could point to another difference between these error-forms; namely that in phoneme masking forward and backward masking are equally common (MacKay, 1969), whereas in the Ranschburg Effect inhibition is commonly stronger for the second member of the pair (forward inhibition) than for the first member (backward inhibition - e.g. Crowder, 1968).

A second possibility is to assert equivalence but to deny the reliability of either MacKay's (1969) analysis of phoneme masking or Experiment VII's analysis of the phonemic Ranschburg Effect. This consideration led me to reconsider MacKay's analysis after Experiment VII had been performed. MacKay analyzed 97 errors including examples (1) and (6) below.

(1) Unglaublich ⟶ Unglaubich

(6) Investitionscheine ⟶ Investionscheine

Now, both errors result in omissions, whereas the phonemic Ranschburg Effect produces substitutions (due, presumably, to the tight experimental constraints). It is conceivable that omissions and substitutions show different behaviours with respect to syllable position (cf. example 4's CV : VC structure). Also, examples (1) and (b) differ in that in example (1) only the repeated consonant /l/ is omitted, whereas in example (b) the phonemic material between the repetitions is also omitted - i.e. example (b) is a haplological error (cf. Section 2.5.4.). A third possibility, therefore, is that segmental replacements and omissions may behave with respect to syllable position in the same manner as the errors observed in Experiment VII, but that haplological errors may depend upon the repeated phonemes sharing identical syllable positions. A predominance of haplologies in MacKay's corpus would explain the discrepancies obtained here.

Clearly, all these proposed reconciliations are highly conjectural, and the writer has lacked access to the data necessary to accept or reject particular proposals. It is only by further experimentation and interrogation of large corpora of speech errors that the issues can be resolved.

CHAPTER 7.

MECHANISMS, FAILURES AND PATHOLOGIES.

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7.1. SUMMARY: THE MAIN POINTS.

Eight experiments constitute the empirical content of this thesis: all were in the style and tradition of orthodox short-term memory experiments, but all derived their inspiration, and their predictions, from psycholinguistic studies of naturally occurring phonemic speech errors. The leitmotif running throughout all the experiments has been the 'error equivalence hypothesis' (cf. Section 2.4.) with its claim that, if the Response Buffer account of speech production and short-term memory is correct, then variables which can be shown to affect a particular form of error in one of the two contexts of language performance (speech or short-term memory) should similarly affect its proposed equivalent error counterpart in the other context.

Experiment I (Sections 3.2. to 3.6) began by postulating equivalence between phonemic Spoonerisms in speech and phonemic transpositions (order errors) in short-term memory. It was noted that both types of error were the commonest in their respective domains, that both obeyed an absolute rule of noninteraction between consonants and vowels, and that both showed rapid decline in frequency of exchange between elements as a function of distance between them. On the basis of studies of Spoonerisms, it was predicted, and demonstrated, i) that consonant transpositions occur more frequently than vowel transpositions which, in turn, occur more frequently than syllable transpositions and ii) that the probability of transposition between two consonants increases as their phonetic similarity (as measured by the number of distinctive feature values held in common) increases. This latter effect was termed the feature similarity effect.

Experiment I also predicted, but failed to find, a contextual similarity effect - i.e. an effect (known to hold true for consonant Spoonerisms) whereby two consonants (say /p/ and /b/) are more likely to transpose if they originate in syllables with identical vowels (e.g. /pe/ and /be/) than if they originate in syllables with different vowels (e.g. /pe/ and /bi/). It was argued, however, that subjects may have employed different mnemonic strategies in coping with the two conditions of Experiment I (an ALL-SAME VOWEL CONDITION and an ALL-DIFFERENT VOWEL CONDITION) - or, alternatively, have experienced different degrees of difficulty in applying the same strategy in the two conditions. Consequently, Experiment II (Sections 3.7. to 3.10) was carried out, again looking for a contextual similarity effect, but on this occasion contrasting ALL-DIFFERENT lists with syllable sequences in which only a critical pair of syllables contained identical repeated vowels (the REPEATED VOWEL CONDITION). On this occasion the contextual similarity effect was found, both for transpositions and (more convincingly) for consonant reversals between the critical pairs of syllables.

Experiment III (Sections 3.11. to 3.14) focussed on substitution rather than transposition errors and, after postulating equivalence with segmental replacement errors in speech (cf. Section 2.5.3.), predicted a feature similarity effect for substitutions. This effect was successfully demonstrated.

Experiment IV (Sections 4.1. to 4.4.) investigated the effects of syllable position on transpositions in short-term memory. Both consonants and vowels showed significant tendencies to transpose with other consonants or vowels which originated in identical, rather than different, syllable positions (initial or final for consonants and pre-consonantal or post-consonantal for vowels). Thus, for example, syllable-initial consonants tended to transpose with other syllable-initial consonants rather than with syllable-final consonants.

Experiment V (Sections 4.5. to 4.8.) continued the investigation of syllable position effects and included a replication of the effect of syllable position on consonant transpositions. Intervocalic consonants (i.e. consonants in - VCV - sequences) were shown not to transpose preferentially with, or be replaced preferentially by, either syllable-initial or syllable-final consonants. This result is discussed in the context of phonological theories of syllable division.

Experiment VI (Sections 5.1. to 5.5.) is the last, and least conclusive, investigation of transpositions in short-term memory. In brief, linguistic stress is shown to have no significant effect upon the distribution of transpositions. This contrasts with the well-attested correlation between stress level and Spoonerisms in speech, and also with an effect of stress on transposition errors in a multiple, repeated recall procedure used by MacKay (1971). Section 5.5. discusses this (apparent?) failure of the error equivalence hypothesis in detail.

Experiment VII (Sections 6.2. to 6.5) and Experiment VIII (Sections 6.6. to 6.9.) were concerned with establishing the existence of a phonemic variety of the Ranschburg Effect in short-term memory (Experiment VII) and then (after proposing error equivalence between the phonemic Ranschburg Effect and the phenomenon of phoneme masking in spontaneous speech) investigating the effect of syllable position on the phonemic Ranschburg Effect. Syllable position was, indeed, found to influence the phonemic Ranschburg Effect (Experiment VIII), but the exact nature of that influence was different from the reported influence of syllable position on phoneme masking in speech (see Section 6.9 for a discussion).

The extent to which the reader finds support in these results for the theoretical position outlined in Chapter 2 and adopted throughout the subsequent chapters will probably depend upon his or her initial predisposition to accept the Logogen Model and its account of short-term memory phenomena. The remainder of this chapter (and, hence, of this thesis) will unashamedly assume the correctness of the basic theoretical framework adopted here (i.e. it will be assumed that the discrepancies between predicted and observed results in Experiments VI and VIII can be reconciled in a way that 'saves' the error equivalence hypothesis and, thus, the theoretical framework). The next section (7.2) will consider some aspects of the detailed mechanisms of the Response Buffer, and this will be followed in Section 7.3 by a discussion of some pathological language phenomena that may be explicable in terms of impairments of the Response Buffer and its associated processes.

7.2. MECHANISMS AND FAILURES.

7.2.1. Wickelgren's context-sensitive, associative theory.

What, then, goes wrong at the Response Buffer when a speech or short-term memory error occurs? Put differently, what sort of mechanisms will err in the same way that humans err when they do? Wickelgren (1969b ; 1976) has put forward a context-sensitive, associative theory of speech production in which preplanned sequences of words are stores as sets of unordered 'context-sensitive allophones' where an allophone is a phoneme with one phoneme specified before and after it. For example, the word struck would be as below, where /#/ represents a word boundary.

$${}_{\#}s_{t} \quad {}_{s}t_{r} \quad {}_{t}r_{\wedge} \quad {}_{r}\wedge_{k} \quad {}_{\wedge}k_{\#}$$

Once the first allophone is activated, a simple left-to-right associative chaining will output the remaining allophones in the desired order. Wickelgren (1969b) acknowledges that such a device would encounter difficulties with a word like barnyard which possesses the units /${}_{a}r_{n}$/ and /${}_{a}r_{d}$/ - that is, two identical phonemes with identical preceding contexts but differing in their right-hand elements, but suggests that this problem might be resolved by 'looking ahead' to see which of the two possible alternatives uses all of the context-sensitive symbols.

If the context-associative model made errors, it would tend to involve confusing pairs of allophones; i.e. pairs whose contextual specifications are the same. MacKay (1970a) argued that a left-to-right associative chaining could explain why reversed phonemes tend to have identical preceding phonemic contexts (a fact which MacKay (1970a) demonstrated), but could not account for the fact that reversed phonemes also tend to be followed by identical contexts. However, it would seem that any device complicated enough to avoid mistakes on words like barnyard would be able to take cognisance of the right-hand specifications of its context-sensitive symbols as well as the left-hand ones (whether such a model could still reasonably be described as associative is a matter for debate). Wickelgren (1976) also suggested that syllable boundaries, like word boundaries, could be marked in the associative sequence and that this would account for the known syllable position constraints on Spoonerisms-constraints which MacKay (1970a) thought damaging to Wickelgren's theory. The context-sensitive associative model has also drawn criticisms from phoneticians (see Kent, 1976; MacNeilage and Ladefoged, 1976), but this is beyond the scope of the present paper.

Fromkin (Introduction to 1973a) opposes the model on the grounds that Spoonerisms, if described in terms of Wickelgren's units, result in a different set of context-sensitive allophones to those in the correct, intended version of the utterance. Thus, if a speaker mispronounces <u>fish</u> (/fɪʃ/) as "shiff" (/ʃɪf/) - one of the errors listed in the Appendix to Fromkin (1973a) - the context-sensitive allophones of the correct form ($_{\#}\text{f}_{\text{ɪ}}\ {}_{\text{f}}\text{ɪ}_{\text{ʃ}}\ {}_{\text{ɪ}}\text{ʃ}_{\#}$) are a different set from those in the error ($_{\#}\text{ʃ}_{\text{ɪ}}\ {}_{\text{ʃ}}\text{ɪ}_{\text{f}}\ {}_{\text{ɪ}}\text{f}_{\#}$). However, the force of this argument rests on the assumption that Spoonerisms should be regarded as errors in the execution of a program which has, itself, been correctly set up (cf. Morton's 1970 : 238) claim that 'Items are always encoded correctly when initially placed in the buffer'.). An alternative possibility, suggested by Whitaker (1970), is that the program of allophones is wrongly set up in the first place and that Spoonerisms occur precisely because the wrong context-sensitive allophones have been selected. It remains to be demonstrated that such a model could account for the <u>mutuality</u> of reversals mentioned earlier.

All this may just go to show the power of immunization - I do not know. For myself, I suspect that the context-sensitive associative theory could, by non-drastic modifications, account for all the observed effects of <u>contextual similarity</u> on order errors (phonemic environment effects, syllabic and/or morphemic position constraints etc.) but I can see no way that such models could account for the influence of intrinsic (feature) similarity on exchanges. That is, in a model where item selection and error proneness are based on contextual association, why should pairs of phonemes which decompose into similar sets of component distinctive features tend to exchange more than pairs of dissimilar phonemes - a phenomenon which Wickelgren (1965; 1966) himself documented?

7.2.2. Broadbent's misselection theory.

Broadbent (1971) attempted to characterize the sorts of short-term memory processes which would tend to make order errors based on intrinsic similarity. According to Broadbent (1971, Ch. 8), order errors are essentially selection errors arising through difficulties in selecting the correct item for response at a particular point in a sequence from a larger set of potential responses. Given that the sizeable majority of phonemic speech and short-term memory errors are misselections from among planned tone-group or stimulus list, it will be assumed here, as a first approximation, that the array of potential responses is limited to those restricted sets.

The array of potential responses must, according to Broadbent (1971), be held in some form of buffer store with each item (phoneme) coded as a bundle of descriptive features whose particular values define that item uniquely. A second system, which Broadbent (1971) terms the address register, must then be postulated. The address register also carries items coded as sets of feature specifications and is responsible for the actual selection process (the buffer store, ex hypothesi, having no generative powers of its own). At each particular point in the sequence, the specification of the desired item coded in the address register is used to select the desired response item from the buffer store, the decision being based upon a comparison of the two feature descriptions.

If the address register is prepared to make probabilistic decisions (that is, if it is prepared to select an item from the buffer store on the basis of, say, nine out of ten shared feature values), then it will be prone to make errors. The errors which occur will tend to involve the misselection of items intrinsically similar to the correct item, where similarity is defined in terms of the number of feature values which the correct item and the error share in common. Contextual and positional similarity effects may be incorporated into this model if the list of features defining each item is extended to include not only articulatory distinctive features but also features specifying syllable or morphemic position, preceding and following phonemes, and all other dimensions of similarity which can be shown to influence the probability of exchange between items. The models would thus be context-sensitive as well as being sensitive to intrinsic similarity.

The recent discussion in this section has adopted Broadbent's (1971) terminology rather than that of the Logogen Model. The question arises as to whether one or both of Broadbent's two entities (the buffer store and the address register) is equivalent in function to the Response Buffer in the Logogen Model. My own inclination is to avoid the terminological temptation to equate the Response Buffer with Broadbent's buffer store, and rather to suggest that the Response Buffer be regarded as equivalent to Broadbent's address register, with his buffer store being a new phonological store in the system (possibly one more intimately connected with the Cognitive System). There is obvious redundancy in a model which codes phonemic information at two loci, and then uses one to select information from the other; I would be only too happy to replace this model with a less redundant one capable of explaining the same well-attested phenomena should someone be able to come up with such an improved model.

7.2.3. Loss of information, silent rehearsal, and inner speech.

Many experiments have been performed in attempts to discover what causes loss of information in immediate recall (see Broadbent, 1971). Some of the best evidence for decay of information comes from experiments by Baddeley, Thomson and Buchanan (1975) who found a decrement in immediate recall of words of long spoken duration (e.g. coerce, nitrate, zygote) as compared with words of short spoken duration (e.g. bishop, wicket, decor,) matched on word frequency, phonemic length and syllabic length. Their results indicate furthermore that memory span is equivalent to the number of words that can be read aloud in two seconds.

If a distinction (or, more plausibly, a continuum) is to be drawn between elaborative rehearsal when subjects rehearse in order to encode a sequence for long-term memory, and maintenance rehearsal as simple overt or covert repetition sufficient to meet immediate task demands, (Craik and Watkins, 1973), then maintenance rehearsal only makes sense if it functions to protect the internal representation of a sequence of items against decay. Decay in the Response Buffer could be countered by outputting long sequences faster than short sequences; such a strategy would explain the result obtained by de Rooij (cited in Nooteboom and Cohen, 1975) that speech segment durations at the beginning of a phrase decrease as the amount of speech remaining to be produced in the phrase increases.

Silent rehearsal is something that subjects in short-term memory tasks do, but in my experience it is not all that pervasive a phenomenon in everyday life (I have never been convinced by the proposition that Nature provided us with a short-term store and rehearsal loop purely to enable us to retain a telephone number in the interval between consulting the directory at one side of a room and dialling at'a 'phone situated, illogically, at the other side). I believe that the rehearsal loop can be given more 'ecological validity' - to borrow a popular phrase - if we follow the suggestion of Locke (1969), Conrad (1972) and others and equate subvocal rehearsal with inner, silent speech. The inner speech/rehearsal loop would then provide the mechanism for detecting phonemic errors in inner speech, as attested by Bawden (1900), Hockett (1968) and Hill (1972).

According to Vygotsky (1934/1962), Kohlberg, Yaeger and Hjertholm (1969) and Conrad (1971), inner speech does not develop in children until the age of five to seven years. One would not, then, expect subvocal rehearsal abilities in children below this age - an expectation for which there is some support in the literature (Chi, 1976: 562).

Verbal memory span increases with age, whereas non-verbal span shows little or no effect of age (Olson, 1973). This, along with the clinical dissociability between verbal and non-verbal span impairments (Shallice and Warrington, 1974) and experiments showing differential performances on words and pictures in various short-term recall tasks (Pellegrino, Siegel and Dhawan, 1975, 1976 a, b), provides evidence that the processes underlying verbal short-term memory are qualitatively different from those underlying recall of non-verbalized sounds or pictures.

The developmental increase in verbal memory span, paralleled as it is by increases in mean utterance length (Brown and Fraser, 1963) and maximum separation between phonemes involved in Spoonerisms (MacKay, 1970b) could be taken to indicate a developmental increase in Response Buffer capacity (or decrease in decay rate), but it is also compatible with increased computational ability, and/or better use of strategies of coding, grouping and rehearsal and/or greater use of lexical and semantic knowledge to boost performance (cf. Olson, 1973; Chi, 1976). One point should be made clear - the Response Buffer is a phonemic storage/retrieval system, not a computational Working Memory (cf. Baddeley and Hitch, 1974). As such, its limitations cannot legitimately be used to "explain" why speakers' utterances do not conform to the rules of a particular grammar: such explanations must be sought elsewhere.

7.3. PATHOLOGIES.

7.3.1. Phonological disorders in aphasia.

Phonological production disorders occur in several of the commonly recognized varieties of aphasia[1]. Thus, phonemic errors occur in the laboriously-articulated telegraphic speech of the non-fluent (alias Broca's, executive or motor) aphasic and in the easily articulated (though frequently paraphasic) speech of the fluent (Wernicke's, receptive, or sensory) aphasic. (In the latter category, the term "literal paraphasia" is often used to describe phonemic errors).

[1] The lower-level articulatory/phonetic problems of dysarthria will not be considered here.

Despite the fact that they occur in clinically very different forms of aphasia, the phonemic errors reported, when viewed apart from the rest of the speech output, appear remarkably similar (and similar, too, to the phonemic tongue slips of normal speakers - see below). As with normal phonemic errors, aphasic paraphasias can be categorized into syntagmatic anticipations, perseverations and reversals (examples 1, 2, and 3 respectively), or paradigmatic segmental replacement errors (example 4) - examples taken from Blumstein (1973).

(1) /hɪstri bʊks/ 'history books' → /bɪstri bʊks/

(2) /biutifəl gr̩l/ 'beautiful girl' → /biutɪfəl br̩l/

(3) 'elephant' → /ɛfələnt/

(4) 'day' → /tei/ (no /t/ in co-text).

Several authors have previously noted the apparent similarity between aphasic errors and normal speech errors (e.g. Lenneberg, 1960; Aitchison, 1976; Marshall, 1977). Recent investigations into phonological aspects of aphasic speech have further substantiated the claim that some forms of aphasic disorder represent a heightened susceptibility on the part of the aphasic to forms of error which normal speakers are also prone to make, though much less frequently (in terms of the theory developed earlier, the heightened susceptibility would be to phonemic mis-selections at the level of the Response Buffer). Thus, a number of studies have reported that in aphasic paraphasias, as with normal tongue slips (cf. Chapter 3), the intended phoneme and the error phoneme (whatever its origin) tend to be phonetically similar, differing in only one or two distinctive features (Green, 1969; Lecours and Lhermitte, 1969; Blumstein, 1973). Also, the likelihood of syntagmatic exchange between two phonemes shows the same decline with increasing distance between the phonemes concerned for aphasic errors as it does for normal errors (Blumstein, 1973 - cf. Section 3.2.1. (iii)). Again, as for normal errors, the majority of aphasic phoneme errors are syntagmatic rather than paradigmatic (approximately 80% of all errors in Lecours and Lhermitte's (1969) study), although the proportion of paradigmatic segmental replacement errors appears consistently higher in aphasic than in normal speech (Talo, 1977).

Production errors have the characteristic that they rarely result in sequences of phonemes not permitted in normal phonology: this is true of both aphasic errors (Blumstein, 1973) and normal errors (Wells, 1951; Boomer and Laver, 1968; Garrett, 1975). Fromkin (Introduction to 1973a) illustrates this by saying that "slips of the tongue" might be Spoonerised into "stips of the lung" or "tips of the slung", but not into "tlip of the sung", because English phonotactic rules do not permit /tl/ to occur at the beginning of English words. Since there seems no way that the Response Buffer could know that a mis-selection will result in a phonologically-impermissible sequence before the error is made, it is more plausible to suggest that such errors are normally "edited-out" by rule systems below the Response Buffer (Laver, 1969, 1977; Morton, 1968).

7.3.2. Selective impairment of auditory-verbal short-term memory.

The model developed here must also, if it is to be accepted, be compatible with the clinical literature on memory disorders (N.B. there is, in any case, no clear distinction to be drawn between disorders of language and disorders of memory). The separation of the Response Buffer from the Cognitive (LTM) System permits explanation of normal memory spans in amnesic patients (Warrington and Weiskrantz, 1973). The fact that the Response Buffer is not the only (or indeed the normal) route of access of verbal input to the Cognitive System allows long-term memory to function at normal levels in patients who show drastically reduced short-term memory performance (Warrington and Shallice, 1969; Warrington, Logue and Pratt, 1971 - see Section 1.3.6). From the model one would expect that patients showing impaired STM would also normally manifest speech production difficulties, and this does, indeed, seem to be the normal pattern (Green and Howes, 1977; Shallice and Warrington, 1975).

There exists, however, at least one patient in the literature who, whilst displaying severely-impaired STM, nevertheless appears to speak normally (the patient J.B., described by Warrington et al, 1971; Shallice and Butterworth, 1977). Assuming J.B.'s speech is not abnormal in some way not revealed by Shallice and Butterworth's 1977 analysis, there is only one locus in the model where functional impairment could result in the observed constellation of symptoms, and that locus is the silent rehearsal loop. If information in the Response Buffer is subject to decay, as the results of Baddeley, Thomson and Buchanan (1975) suggest, then a patient with impairment of the silent rehearsal loop would, when attempting memory span or similar tasks, be unable to maintain the trace strength of early list items whilst registering later items in the Response Buffer. Such a patient's situation may be comparable with that of the subjects in experiments by Baddeley et al (1975), Smith (1975) and Murray (1967) whose STM was impaired considerably through being required to articulate simple words or syllables constantly during presentation of the to-be-repeated items.

This tentative hypothesis as to the nature of J.B.'s disorder generates an interesting prediction as regards her ability to interpret orthographically-regular nonwords which are homophonous with real words (e.g. frute, bair). Ex hypothesi, J.B. should be able to read such nonwords aloud and, by hearing the word spoken, arrive at a semantic interpretation. However, since (within the model) the rehearsal loop also mediates silent 'phonic' recoding of words for which there is no visual representation in the Logogen System (Morton, in press) the patient should be unable to semantically decode (e.g. provide a synonym for) homophonous nonwords. This prediction is a fairly strong one in the sense that it is readily testable whilst not being self-evident. If the prediction proves false, then the model is incorrect and stands in need of modification or abandonment.

In a recent paper, Shallice (in press) has set out his views concerning the interrelationship between STM and speech processing in greater detail. He proposes that the speech-based short-term store exists to retain the surface structure of speech in case the initial parsing falls behind speech input in real-time, or even fails completely, as in Lashley's (1951) well-known sentence, "Rapid righting with his uninjured hand saved from loss the contents of the capsized canoe". This theory, in which the short-term store operates in parallel with the normal process of lexical look-up and parsing, is compatible with Warrington, Logue and Pratt's (1971) observation that clinical patients with reduced short-term memory performance (Section 1.3.6.) also had difficulty interpreting instructions containing much non-redundant information, e.g. "Put the red circle between the yellow triangle and the green triangle".

Now, it is one of the tenets of the Logogen Model that, in the words of Morton (1970: 213), "The act of response availability appears to be a sufficient condition for the subjective phenomenon of the perception of a word when combined with the general information that particular sensory analyzers have been operating." That is, the final stage in word recognition, whether in speech perception or reading, occurs when the phonological form of the word becomes available in the Response Buffer as a potential verbal response - this final stage corresponds to the moment of conscious perception of the word.

If this account is extended to the perception of running speech or text, then the Response Buffer can be invoked as a back-up phonological store of the sort required by Shallice (in press), whilst retaining its primary function in speech production. The Response Buffer should be limited to the post-lexical phonological storage of the most recent tone-group (cf. Section 2.3.), which should in turn set a limit on veridical recall of surface structure from a single presentation (Note, however, that LTM must have some means of storing the precise wording of text in addition to the gist, otherwise an actor's job would be impossible - one requires more from Hamlet than the gist of the famous 'To be or not to be' soliloquy.

7.4. CODA.

As the Logogen Model stand, it is clearly an over-simplified first approximation to a model of language performance and memory. Postulating a functionally-distinct entity like the Response Buffer does not constitute an explanation of how that buffer is supposed to work, rather it is an act which serves to delimit an area of ignorance and separate it off for further examination. Models must grow with the data they purport to explain, but they must do so in a strictly-disciplined manner. The too-hasty proliferation of boxes within boxes has left many an exasperated psychologist asking himself whether it is really necessary to suffer the bins and arrows of outrageous functional models. However, if it is considered worthwhile to persist with models of the type discussed here (and that decision, I propose, should be largely based on assessments of their predictive fruitfulness), then the model as it stands is in need of careful development, and I have given some indications of ways in which this might be done.

Slips of the tongue have been immensely valuable in guiding the formation of models of the production of speech. However, as the questions asked about speech errors become more detailed and more precise, it becomes increasingly hard to answer them by reference to naturally-occuring slips (Garrett, 1976). If it is accepted that short-term memory procedures can be used to induce speech errors under experimental conditions, where variables may be controlled and varied independently, then the technique offers a useful addition to the armoury of those who are trying to understand speech production as an aspect of human performance. In return, the laboratory-bound study of short-term memory might be restored to some degree of contact with the real world and real skills, like speaking.

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Abbreviations.

B.J.P. = British Journal of Psychology.

J.A.S.A. = Journal of Acoustical Society of America.

J.E.P. = Journal of Experimental Psychology.

J.E.P. (H.L. &. M.) = Journal of Experimental Psychology, (Human Learning and Memory).

J.V.L.V.B. = Journal of Verbal Learning and Verbal Behaviour.

Q.J.E.P. = Quarterly Journal of Experimental Psychology.

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